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TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION (TAACE). PHASE 0.--ETC(U)
MAY 80 G J BARBATO, R P MADERO, G A SEXTON F33615-78-C-3614
AFWAL-TR-80-3030-VOL-2 NL

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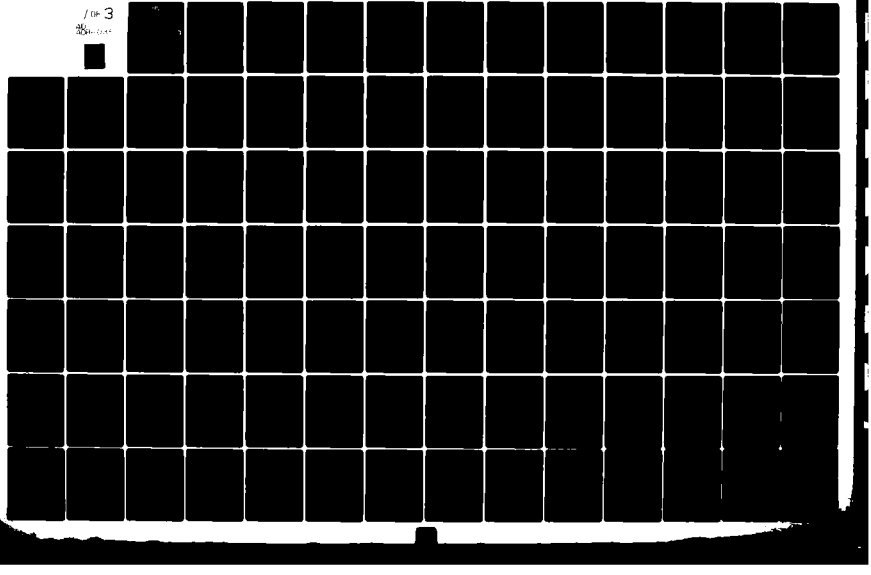

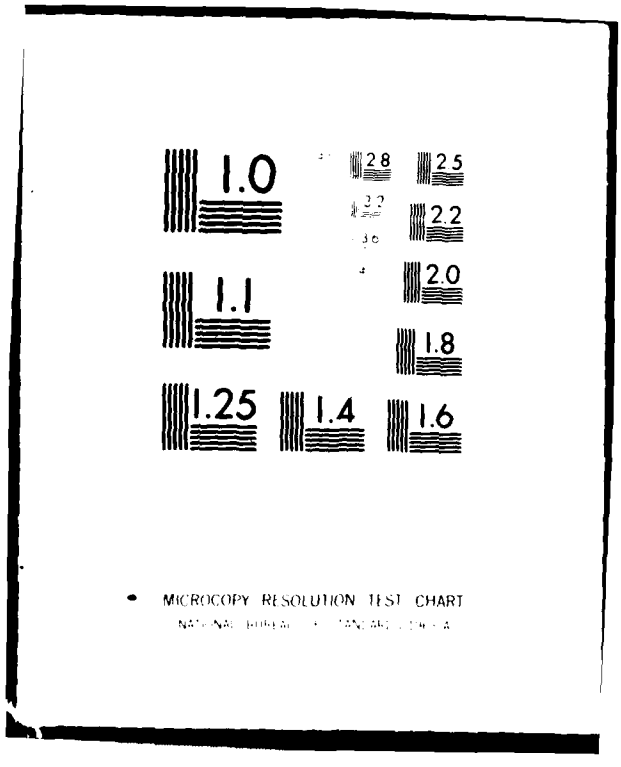
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AFWAL-TR-80-3030
VOLUME II

LEVEL II

AD A088035

TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION (TAACE) PHASE 0 - ANALYSIS AND MOCKUP

VOLUME II: SUMMARY OF DATA

The Bunker Ramo Corporation
Electronic Systems Division
Westlake Village, California

May 1980

TECHNICAL REPORT AFWAL-TR-80-3030, VOLUME II

Final Report for Period June 1978 - May 1979

FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Acting Chief
Flight Control Division

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AIR FORCE/56780/21 July 1980 — 200

(19) TR-80-3030-Vol-2

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Inertial Navigation System	Workload	
Avionics Modernization	Tanker	
Horizontal Situation Display	Control/Display Criteria	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a mockup cockpit design study which was performed in support of the USAF KC-135 Avionics Modernization Program. The preliminary issues addressed during the study were the avionics control and display criteria to be met in the event of a reduction in crew size for the KC-135. The study results indicated that two pilots and a boom operator could successfully fly the depicted mission scenario by reallocating various crew tasks and by utilizing 1980 state-of-the-art avionics/navigation systems.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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This report is presented in three volumes. Volume I describes the TAACE program and the mockup evaluation results. Volume II is a summary of the data resulting from the study, and Volume III is a detailed description of the mission scenario used during the evaluation.

FOREWORD

This report documents the first phase of a two-phase effort called the Tanker Avionics/Aircrew Complement Evaluation (TAACE). The results obtained in an experimental cockpit mockup design effort concerned with developing the crew station avionics criteria to be met for a 3-man crew complement (pilot, copilot, boom operator) to complete all KC-135 mission requirements without compromise to either mission performance or aircraft operational safety are reported herein.

The program is being conducted under an Air Force Systems Command Memorandum of Understanding between the Aeronautical Systems Division, KC-135 Avionics Modernization Program Office (ASD/SD-28) managed by Mr. Tom Biggs, and the Flight Dynamics Laboratory (AFWAL/FIGR), Wright-Patterson AFB, Ohio. The Flight Dynamics Laboratory portion of the program is managed by Mr. Richard Moss, Program Manager, AFWAL/FIGR, and Lt Donald Seyler, Lead Engineer: Crew Systems Design Phase, AFWAL/FIGR.

The report was prepared in part by the on-site Human Factors Group, located at Wright-Patterson AFB, Ohio, Electronic Systems, Bunker Ramo Corporation, Westlake Village, California, under USAF Contract No. F33615-78C-3614, Project No. 23915100. Mr. Robert A. Bondurant, III (AFWAL/FIGR) is the contract monitor.

The authors wish to acknowledge the assistance from Lt Mark Hussey and Lt Tom Roberts, formerly of AFWAL/FIGR, for their essential contributions concerning the present study experimental design and set-up, testing, and report preparation. In addition, recognition is given to Mr. Tom Molnar (AFWAL/FIGL) for critical assistance in the development of the nav management system; Mr. John Kozina (Bunker Ramo) and Mr. Fritz Baker (Lear Siegler) for engineering assistance in experimental equipment integration; Mr. Rick Helton and Mr. Tom Payton (AMFTD) for construction of the KC-135 mockup; Capt Steve Kolet (AFWAL/FIGX) for extensive consulting regarding KC-135 operations; and Cindy Gier and Sandy Dickey (Bunker Ramo) for untiring administrative support.

This research effort was performed between June 1978 and May 1979.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

A/A	Air to Air
AC	Alternating Current
ADF	Automatic Direction Finding
ADI	Attitude Director Indicator
AFFDL	Air Force Flight Dynamics Laboratory
AHRS	Attitude Heading Reference System
APU	Auxiliary Power Unit
A/R	Air Refueling
ARA	Airborne Radar Approach
ARCP	Air Refueling Control Point
ARCT	Air Refueling Control Time
ARIP	Air Refueling Initial Point
ATC	Air Traffic Control
BAR	Begin Air Refueling
BDHI	Bearing Distance Heading Indicator
CADC	Central Air Data Computer
CAS	Calibrated Airspeed
C/D	Control/Display
CDU	Control/Display Unit
CG	Center of Gravity
CONUS	Continental United States
CRT	Cathode Ray Tube
DC	Direct Current
DF	Direction Finder
DME	Distance Measuring Equipment
DR	Dead Reckoning

LIST OF ABBREVIATIONS

(cont.)

EAR	End of Aerial Refueling
EGT	Exhaust Gas Temperature
EMP	Electromagnetic Pulse
EPR	Engine Pressure Ratio
FL	Flight Level
FM	Frequency Modulation
GA	Go Around
GCI	Ground Controlled Intercept
GMT	Greenwich Mean Time
GS	Groundspeed
HF	High Frequency
HSD	Horizontal Situation Display
HSI	Horizontal Situation Indicator
IAS	Indicated Airspeed
IFF	Identification, Friend or Foe
IFF/SIF	Identification, Friend or Foe/Selective Identification Feature
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
JN	Jet Navigation
MPD	Multipurpose Display
MRT	Military Rated Thrust

LIST OF ABBREVIATIONS

(cont.)

NATO	North Atlantic Treaty Organization
NM	Nautical Miles
PPSN	Present Position
RGA	Rotate and Go Around
RMI	Radio Magnetic Indicator
RPM	Revolutions Per Minute
R/T	Receiver/Transmitter
RZ	Rendezvous
RZIP	Rendezvous Initial Point
SAC	Strategic Air Command
SELCAL	Selective Call
SKE	Station Keeping Equipment
TAACE	Tanker Avionics/Aircrew Complement Evaluation
TACAN	Tactical Air Navigation
TAS	True Airspeed
TOLD	Take-Off and Landing Data
TRT	Take-Off Rated Thrust
UHF	Ultra High Frequency
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
VVI	Vertical Velocity Indicator
WX	Weather

SUMMARY

This report documents a mockup cockpit design study which was the first phase of a two-phase effort currently being performed in support of the USAF KC-135 Avionics Modernization Program. The report is presented in three volumes: Volume I describes the experimental design and summary of results; Volume II presents the study data; and Volume III details the mission scenario.

To address the cockpit design issues relating to eliminating the navigator from the KC-135 tanker aircraft, a full scale mockup was designed and was "flown" by operational aircrews over a representative mission profile. The results of the study are presented in this paper. To develop the experimental design around answering the question of how to eliminate the navigator position from the aircraft, a mission analysis and composite mission scenario were constructed, and three candidate suites of available control/display avionics were identified and arranged in the full-size representative KC-135 cockpit mockup. Nine fully qualified Strategic Air Command tanker (KC-135) aircrews, consisting of two pilots and a boom operator, "flew" the composite mission scenario and the three candidate avionics suites. They thereby provided a subjective data base that formulates the results and conclusions of the present study.

The primary issues addressed during this study were the avionics control and display criteria to be met in the event of the reduction of the crew complement for the KC-135. The resultant data of the experiment suggested that subject crews were strongly supportive of a reduced crew complement only if certain present and useful KC-135 avionics hardware is relocated while other hardware that has become unacceptably outdated or has outlived its usefulness is significantly updated. The crew members were very much in favor of including as new hardware a navigation management system that could display at least six upcoming waypoints at a time with an almost infinite waypoint storage capacity. Additional capabilities of the system included fuel management/status update and display, automatic present position update in relation to flight plan, and the ability to calculate center of gravity and takeoff/landing computations. During refueling operations, holding and rendezvous patterns could also be preprogrammed into the system.

Another major modification to the cockpit design which was judged by the crews to be indispensible for mission accomplishment with a reduced crew size was the horizontal situation display. This device, which replaced the standard horizontal situation indicator, not only could display that standard information, but also allowed the selection of a moving map alone or with weather, ground mapping, or radar beacon overlays. In addition, certain

other flight parameters such as glide slope, groundspeed, course, and time and distance to the next waypoint were available on the perimeter and at the corners of the display itself.

Other changes to the current KC-135 avionics layout rated highly by the crew members were the use of vertical-scale engine instruments and the inclusion of a caution/warning annunciator panel. This panel consolidated all caution and warning indicators into one area of the front instrument panel directly in view of the pilot and copilot. The panel area was made available through the use of the vertical-scale instruments.

It should be noted that although the crew station reconfigurations presented in this report were analyzed in the context of a reduced crew complement (i.e., without a navigator), many of the findings about enhanced ability to accomplish the mission while, at the same time, reducing crew workload are applicable even without eliminating the navigator crew position. Given the rapidly increasing amount of information that must be assimilated by the pilot and copilot in a potentially expanding hostile environment, it becomes imperative that advanced technology in the form of multipurpose displays and computers be incorporated in crew systems designs to perform some of the paperwork/navigation computations which presently consume a significant amount of time and substantially contribute to aircrew workload.

Based on the results of this study, it can be stated that accomplishment of the aerial refueling mission is feasible with a two pilot, one boom operator flight crew by reallocating crew tasks and by utilizing 1980 state-of-the-art crew systems, including a navigation management system, electronic horizontal situation/multipurpose displays, and generally upgraded avionics systems.

TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION

MOCKUP EVALUATION PHASE

VOLUME II: QUESTIONNAIRE DATA

This volume contains three sections which comprise the results of the questionnaires used during mockup evaluation. Section A includes the rating scale packages used by the pilots, copilots, and boom operators to complete the questionnaires, Section B includes the responses to these questionnaires summarized for each design update and each question, Section C contains the comments made by the subjects during debriefing sessions and in response to questionnaire inquiries.

Section A

Rating Scale Packages Used by the Pilots, Copilots, and Boom Operators in Completing the Questionnaires

PILOT/COPILOT RATING SCALE PACKAGE

The purpose of the questionnaires that you are going to be filling out is to determine as accurately as possible your feelings and preferences about the varied crew station configurations to which you will be exposed. Through the questionnaires, we will be able to document your opinion and objectively analyze the results of the experiment. The questionnaires are designed to help you think about each crew station design (both during and after each "flight") so that you can help us better assess each design's good and bad points. We ask that you be aware of each design's shortcomings (as well as their strong points) and be thinking about better ways to configure each design during each "flight".

When completing the questionnaires, make any comments that you see fit anyplace in the questionnaire (there is no need to restrict yourself to the "comments" sections). Please fill out the questionnaires as best you can -- we know that at times they may appear too tedious and lengthy but because we are limited in the number of subject crews at our disposal, we must obtain maximum data from you!

DEFINITIONS

During the mockup flights you will be asked to rate the operation of different flying tasks. The tasks you will be rating are communications, navigation, piloting, paperwork, and "other" tasks. Each of these groups of tasks are defined below:

COMMUNICATION - The operation of all communications equipment and communication on that equipment -- tuning, transmitting, receiving, and frequency recognition for all communication radios.

NAVIGATION - The operation of all navigation equipment and navigation on the information provided -- tuning, receiving, waypoint programming, interpreting information on flight instruments, interpreting guidance information, and ground mapping radar.

PILOTING - Aircraft maneuvering, airspeed control, mission control and command, and SKE.

PAPERWORK - Calculating take-off and landing data, CG computation, AFTO Form 781, mission progress forms, fuel log, and other tasks involving "paper and pencil" computations.

"OTHER" TASKS - Aircraft subsystems controls, weather radar, crew coordination/briefings, see and avoid, and checklists.

RATING SCALES

During the mockup flights, you will be asked to rate workload and equipment for quality and capabilities. The three scales to be used are given as follows:

Scale I (Quality Level)

Rating	
10	Excellent (Needs no improving)
9	Very Good
8	
7	Good
6	
5	Fair, butuseable
4	
3	Poor (Almost not useable)
2	
1	Very bad
0	Unacceptable - not useable

Scale II (Workload Level)

Rating	
10	Overload
9	Extreme
8	
7	Significant
6	
5	Moderate
4	
3	Occassional
2	
1	Seldom
0	No work

Scale III (Requirements/Capabilities)*

Rating	
10	Would or did enhance mission performance so much as to be absolutely necessary to perform the mission.
9	Would or did enhance mission performance greatly - extremely useful. Requirement recommended.
8	
7	Would or did noticeably enhance mission performance - quite useful. Requirement partially recommended.
6	
5	Would or did enhance mission performance somewhat - useful, but not required.
4	
3	Wouldn't or didn't really enhance mission performance - only sometimes useful.
2	
1	Wouldn't or didn't enhance mission performance whatsoever- not useful.
0	Couldn't use it even if it was available.

*This scale is a continuum from an "absolute necessity" rating (10) to an "absolutely could not use it" rating (0).

EXAMPLES OF NAV MANAGEMENT "PAGES"

NAV AIDS

AA	AB	AC	AD
AE	AF	AG	AH
AI	AJ	AK	AC
AM	AN	AO	AP
AQ	AR	AS	AT

NAV AID DATA

EDBB	TEMPLEHOF		
PSN	N 523114 E0103412		
CHAN	89		
FREQ	114.20	321	382
	415	DF	GCA
	ILS		

◊ FLT PLAN

FROM	EDAF		0368
280	LL 1	97	4000
037	BD 1 HOLD	102	FL70
062	BD 2	36	"
351	HAM	12	FL190

WAYPOINT DATA

◊ WPT BERRY N531140 E0103220 FFO 307/124

◊ GMT 1410:10

FLT PLAN→ →ETA 1429:45 →TTW 19:35 →DTW 163.9

GS 245

PSN FROM BERRY 179/163.9

PRESENT POSITION

◊ N422810 W1290736

◊ GMT 1219:10

TAS 355 GS 245

WIND 228/106 DRIFT L 10

◊ IDENT RAD/DIST FROM:

OSCAR 357/128

◊ CENTER OF GRAVITY (CG)

BASIC WT _____

CREW WT _____

FUEL _____

#1 MAIN _____

#2 MAIN _____

FUEL STATUS

LBS X 100

FB→378

2→149 CW→475 3→149

1→138 AB→417 4→138

1R→28 UD→142 4R→28

TOTAL→2067

◊ TOLD

TAKEOFF DATA

GROSS WT	221300
RWY HDG	140
RWY LGTH	11354
RWY GRADE	0
RWY RCR	21

◊ HOLD/RZ

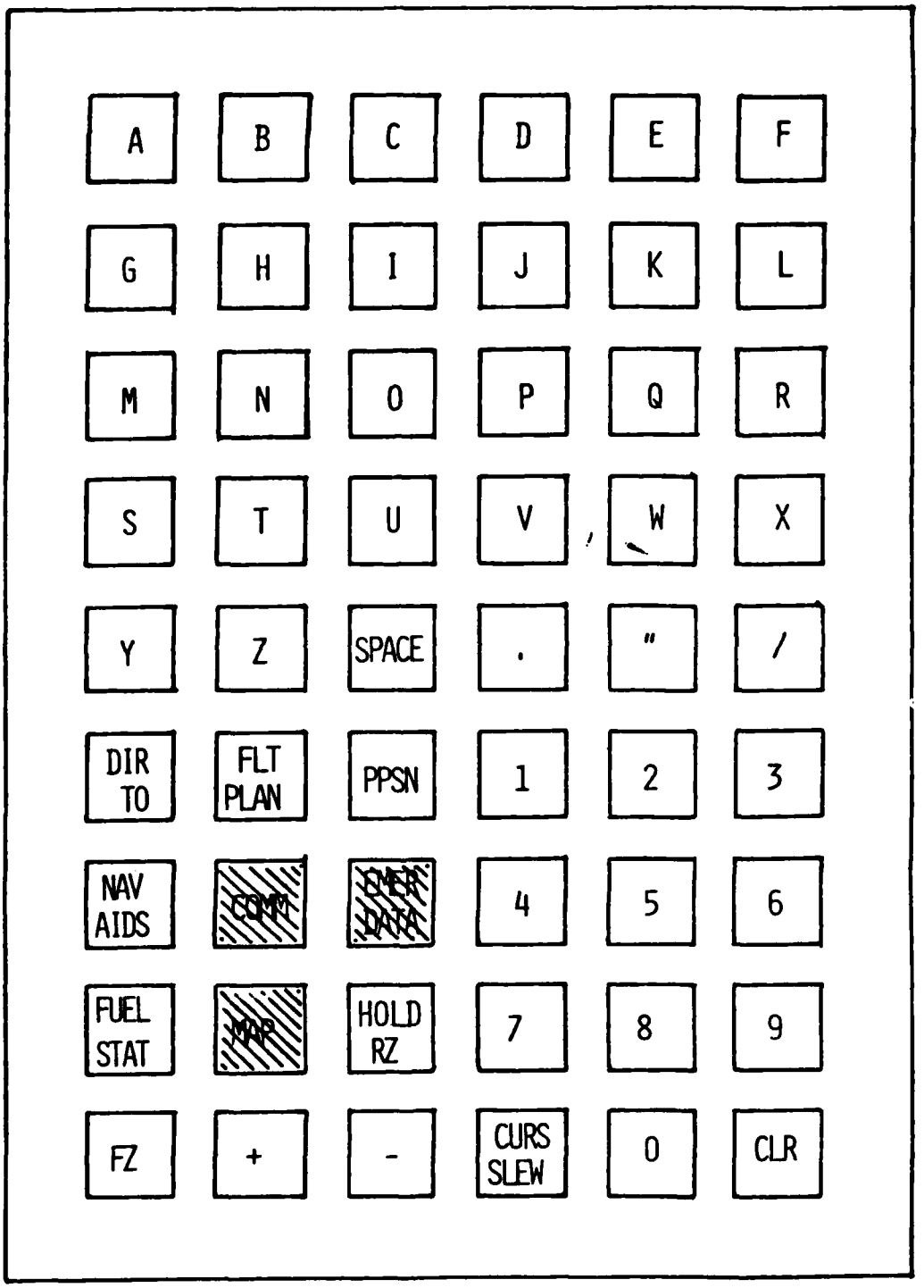
INB CRS 270

TURNS R

INB LEG-MILES 5

PUSH TO INSERT

NAV MANAGEMENT CDU KEYBOARD



Represents functions that either were not operable or were changed completely

BOOM OPERATOR RATING SCALE PACKAGE

The purpose of the questionnaires that you are going to be filling out is to determine as accurately as possible your feelings and preferences about the varied crew station configurations to which you will be exposed. Through the questionnaires, we will be able to document your opinion and objectively analyze the results of the experiment. The questionnaires are designed to help you think about each crew station design (both during and after each "flight") so that you can help us better assess each design's good and bad points. We ask that you be aware of each design's shortcomings (as well as their strong points) and be thinking about better ways to configure each design during each "flight".

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COMMUNICATION - The operation of all communications equipment and communication on that equipment -- tuning, transmitting, receiving, and frequency recognition for all communication radios.

NAVIGATION - The operation of all navigation equipment and navigation on the information provided -- tuning, receiving, waypoint programming, interpreting information on flight instruments, interpreting guidance information, and ground mapping radar.

AERIAL REFUELING - Includes refueling receivers, the operation of all refueling related equipment, and the performance of specified refueling computations.

PAPERWORK - Calculating take-off and landing data, CG computation, AFTO Form 781, mission progress forms, fuel log, and other tasks involving "paper and pencil" computations.

"OTHER" TASKS - Aircraft subsystems controls weather radar, crew coordination/briefings, see and avoid, and checklists.

RATING SCALES

During the mockup flights, you will be asked to rate workload and equipment for quality and capabilities. The three scales to be used are given as follows:

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Rating	
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9	Very Good
8	
7	Good
6	
5	Fair, butuseable
4	
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Rating	
10	Overload
9	Extreme
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7	Significant
6	
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2	
1	Seldom
0	No work

Scale III (Requirements/Capabilities)*

Rating	
10	Would or did enhance mission performance so much as to be absolutely necessary to perform the mission.
9	Would or did enhance mission performance greatly - extremely useful. Requirement recommended.
8	
7	Would or did noticeably enhance mission performance - quite useful. Requirement partially recommended.
6	
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3	Wouldn't or didn't really enhance mission performance - only sometimes useful.
2	
1	Wouldn't or didn't enhance mission performance whatsoever- not useful.
0	Couldn't use it even if it was available.

*This scale is a continuum from an "absolute necessity" rating (10) to an "absolutely could not use it" rating (0).

Section B

Summarized Responses to the Mockup Questionnaires

PILOT PRE-MOCKUP DATA

Please indicate your present crew qualifications:

3 Instructor Pilot

6 Aircraft Commander

_____ Copilot

Indicate the type of aircraft you have flown (since aircrew training) and the approximate hours of flying time for each aircraft:

AIRCRAFT	HOURS
KC - 135	10130 (Average Per Crew: 1125.56)
KC - 97	4400
C - 124	1800
F - 86DL	1300
F - 102	300
F - 104	500
HH - 19	40
HH - 43F	300
O - 1	15
O - 2	10
T - 29	1800
T - 33	500
T - 37	60
T - 38	100

KC-135: High - 2200 Hrs; Low - 500 Hrs.

Indicate the level of experience you have with the following possible KC-135 missions:

	None	Familiar Only	Trained Not Qualified	Fully Qualified
1. Simulated EWO		1		8
2. Single tanker offloading to a cell of receivers				9
3. Lead tanker in a cell			1	8
4. High latitude (polar) operations	2	3	1	3
5. Overwater fighter drags			1	8
6. No. 2 or 3 tanker in a cell of tankers				9

Estimate the % of your missions when a mission change is received after departure to require refueling at a different location than that planned before launch. (Average) 7.1 %

Estimate the number of times you have accomplished an airborne radar-directed approach when the ceiling/visibility was within 1000 feet and 1 mile of published non-precision minima. (Average) 1.0

Estimate the number of out of country (USA) tanker deployments you have had and the total number of months spent on tanker deployments.

Out of country no. of deployments: (Average) 9.78

Total no. months on tanker deployments: (Average) 7.83

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(a). How would you rate the present communications capabilities of the KC-135? (Scale I) 6.33

(b). How would you rate the present navigation capabilities of the KC-135? (Scale I) 5.56

(c). How would you rate the present piloting (aircraft maneuvering, airspeed control, see and avoid, mission control) and associated capabilities of the KC-135? (Scale I) 7.5

(d). How would you rate the present aerial refueling and associated capabilities of the KC-135? (Scale I) 8.11

(e). How would you rate the present overall capabilities of the KC-135? (Scale I) 6.56

Please rate the adequacy of the present KC-135 crew station lighting. (Scale I)

Day: 7.78

Night: 5.89

COPILOT PRE-MOCKUP DATA

Please indicate your present crew qualifications:

1 Instructor Pilot

_____ Aircraft Commander

8 Copilot

Indicate the type of aircraft you have flown (since aircrew training) and the approximate hours of flying time for each aircraft:

AIRCRAFT	HOURS
KC - 135	10640 (Average: 1182.22)
KC - 97	1515
C - 47	8
HH - 3E	380
T - 37	250
T - 38	307
U - 4	20

KC-135: High - 4600 Hrs. (IP); Low - 80 Hrs.

Indicate the level of experience you have with the following possible KC-135 missions:

	None	Familiar Only	Trained Not Qualified	Fully Qualified
1. Simulated EWO	1		1	7
2. Single tanker offloading to a cell of receivers		1		8
3. Lead tanker in a cell			1	8
4. High latitude (polar) operations	3	1		5
5. Overwater fighter drags	1			8
6. No. 2 or 3 tanker in a cell of tankers				9

Estimate the % of your missions when a mission change is received after departure to require refueling at a different location than that planned before launch. (Average) 6.94 %

Estimate the number of times you have accomplished an airborne radar-directed approach when the ceiling/visibility was within 1000 feet and 1 mile of published non-precision minima. (Average) 1.0

Estimate the number of out of country (USA) tanker deployments you have had and the total number of months spent on tanker deployments.

Out of country no. of deployments: (Average) 4.67

Total no. months on tanker deployments: (Average) 4.44

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(a). How would you rate the present communications capabilities of the KC-135? (Scale I) 6.44

(b). How would you rate the present navigation capabilities of the KC-135? (Scale I) 5.5

(c). How would you rate the present piloting (aircraft maneuvering, airspeed control, see and avoid, mission control) and associated capabilities of the KC-135? (Scale I) 7.22

(d). How would you rate the present aerial refueling and associated capabilities of the KC-135? (Scale I) 7.89

(e). How would you rate the present overall capabilities of the KC-135? (Scale I) 6.67

Please rate the adequacy of the present KC-135 crew station lighting. (Scale I)

Day: 8.89

Night: 6.0

BOOM OPERATOR
PRE-MOCKUP AND
POST-MOCKUP DATA

Please indicate your approximate amount of total flying time.

KC 135 9545 hrs. (Average per crew: 1060.56)

Other Aircraft 3500 hrs.

KC-135: High - 2600 Hrs.; Low - 380 Hrs.

Indicate your present crew position.

Boom Operator 5

Instructor 4

Using Scale I, please rate the adequacy of the present KC-135 boom station:

(1) Overall controls and displays

7.0 Day

6.44 Night

(2) Station lighting

7.78 Day

6.0 Night

Please rate on a scale of 1 to 10 how willing you would be to perform inflight duties that you do not now perform (assuming this additional crew responsibility was accompanied with an increase in rating and pay):

Circle one number:

1 2 3 4 5 6 7 8 9 10

Very opposed — Very eager

Pre-mockup rating: 9.56

Post mockup rating: 9.56

From the following list of items, please indicate which you feel you could perform with no training and those which you could perform with some training (regardless of whether you would be willing to perform them):

	Requires No Training		Some Training Required	
	Pre-Mockup	Post Mockup	Pre-Mockup	Post Mockup
Read Checklists	9	8	0	1
Copy & decode messages	3	2	6	7
Monitor present position and progress	1	4	8	5
A/R fuel control (with pumps & gages at boom station)	4	7	5	2
Tune comm radios	7	6	2	3
Tune nav radios	5	6	4	3
Comm with cell formation	6	7	3	2
Comm with command post	8	9	1	0
Rendezvous communication	2	3	7	6
Monitor weather radar	2	2	7	7
Monitor ground mapping radar	1	4	8	5
Monitor engine instruments	8	8	1	1
Monitor caution/warning indicators	7	8	2	1
Fuel management	5	6	4	3
Monitor flight instruments	5	8	4	1
Outside watch	9	9	0	0
Airborne radar approach (direct)	0	1	9	8
Map read (monitor position on JN chart)	3	4	6	5
Complete AFTO Form 781	8	7	1	2
Compute weight and balance	9	9	0	0
Complete flight log (mission progress)	2	2	7	7
Compute takeoff and landing data	0	2	9	7

MOCKUP EVALUATION

How realistic was the mockup experience? (check one)

_____ a). Just like real life; you could easily imagine being in an actual flight.

__5__ b). A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the situation.

__2__ c). Similar to a real experience; you had some difficulty imagining yourself in an actual flight.

__2__ d). Although unreal, it aided in role playing and, therefore, enhanced the realism of the flight.

_____ e). Barely similar to a real experience; you had great difficulty imagining yourself in an actual flight.

_____ f). Completely unlike real life experience; you could never imagine being in an actual flight.

How did the unrealistic aspects of the mockup influence your answers on the questionnaire? Were you most likely to underestimate or overestimate the difficulty of the following tasks?

	Overestimate	Underestimate	Neither
Communication tasks	1	2	3
Navigation tasks	1	5	2
Paperwork tasks		7	3
A/R tasks		1	2
Rz tasks	1	5	1
Other tasks (not listed above)	1		1

How representative of a tanker mission was the mission scenario?

__2__ a). an excellent representation

__6__ b). a good approximation

__1__ c). a fair approximation

_____ d). a poor approximation

_____ e). a very bad approximation

PILOT DESIGN EVALUATION RESULTS

MINIMUM

Compared to current tanker operations, rate how pilot/copilot workload would be affected if the navigator was replaced with dual INS integrated with the flight director and HSI, the boom operator was given more/upgraded responsibilities, and the present KC-135 individual control and display units were generally left intact (much like the configuration you just flew):

MODERATE

Rate how pilot/copilot workload would be affected if the KC-135 dedicated navigation controls and display units were replaced by a nav management system as conceptualized in the previous configuration:

MAJOR

Rate how pilot/copilot workload would be affected if the present KC-135 individual control and display units were replaced by an integrated communication/navigation radio frequency tuner:

0	1	2	3	4	5	6	7	8	9	10
Greatly increased		Moderately increased		Slightly increased	No change	Slightly decreased		Moderately decreased		Greatly decreased

MINIMUM: 2.3

MODERATE: 5.0

MAJOR: 5.67

Please rate the quality of the information presented on the following displays: (Scale I)

MINIMUM	MODERATE	MAJOR	
6.56	8.88	8.67	Navigation displays
6.44	9.13	8.78	A/C engine and system instrumentation
6.78	8.38	7.33	Fuel management controls/displays
5.67	8.5	7.33	Caution/warning system
6.38	8.0	8.0	A/C subsystems control indicators
NA	9.0	8.56	Nav mgt system control/display units
NA	8.75	8.88	Energy management (EPR command)
NA	NA	7.67	Integrated comm/nav frequency tuners

Please rate the capabilities provided by the following systems/displays (this rating is independent of how you rated the quality of the information): (Scale III).

MINIMUM	MODERATE	MAJOR	
7.89	[illegible]	8.22	Navigation displays
6.78	[illegible]	7.22	A/C engine and system instrumentation
6.56	8.63	8.89	Fuel management controls displays
6.89	8.13	6.44	Caution/warning system
7.38	7.38	7.22	A/C subsystems control indicators
NA	9.25	8.22	Nav mgt system control/display units
NA	7.88	6.88	Energy management (EPR command)
NA	NA	5.56	Integrated comm/nav frequency tuners

Could the 3-man flight crew (upgraded boom operator) accomplish the preceding KC-135 mission:

	MINIMUM		MODERATE		MAJOR	
	Yes	No	Yes	No	Yes	No
With all avionics operational?	7	2	9	0	9	0
Without the autopilot, but with all other avionics operational?	4 (2 - Unsure)	3	8 (1 - Unsure)	0	8 (1 - Unsure)	0
Without the dual INS, but with all other avionics operational?	1 (1 - Unsure)	7	N/A		N/A	
Without the autopilot and dual INS, but with all other avionics operational?	0 (1 - Unsure)	8	N/A		N/A	
Without the nav mgt system but with all other avionics operational?	N/A		2 (2 - Unsure)	5	2	7
Without the autopilot and nav mgt system but with all other avionics operational?	N/A		1 (1 - No Response)	7	(Omitted)	
Without the integrated comm/nav frequency tuners but with all other avionics operational?	N/A		N/A		7 (1 - Unsure)	1
Without the control/display unit for fuel mgt, CG, checklists and takeoff and landing data but with all other avionics operational?	N/A		N/A		7	2
Without the upgraded boom station?	N/A		5 (1 - Unsure) (1 - No Response)	2	6	3

Could a 2-man flight deck crew (without boom operator assistance) accomplish the preceding KC-135 mission:

	MINIMUM		MODERATE		MAJOR	
	Yes	No	Yes	No	Yes	No
With all avionics operational?	5 (1 - Unsure)	3	7	2	8	1
Without the autopilot, but with all other avionics operational?	3 (2 - Unsure)	4	4 (2 - Unsure)	3	4 (2 - Unsure)	3
Without the dual INS, but with all other avionics operational?	1 (1 - Unsure)	7	N/A		N/A	
Without the autopilot and dual INS, but with all other avionics operational?	0 (1 - Unsure)	8	N/A		N/A	
Without the nav mgt system but with all other avionics operational?	N/A		2 (1 - Unsure)	6	2	7
Without the autopilot and nav mgt system but with all other avionics operational?	N/A		0 (1 - Unsure)	8	(Omitted)	
Without the integrated comm/nav frequency tuners but with all other avionics operational?	N/A		N/A		6 (1 - Unsure)	1
Without the control/display unit for fuel management, CG, checklists and takeoff and landing data but with all other avionics operational?	N/A		N/A		6	3
Without the unmanned boom station?	N/A		4 (1 - Unimportant)	4	5	4

Using Scale I, please rate the quality of the information contained on the following special function pages of the nav management system. In addition, please put your rating into what you feel to be the most appropriate "Information Amount" column.

	MODERATE Information Amount				MAJOR Information Amount			
	Insufficient	Sufficient	Excessive	Average Rating	Insufficient	Sufficient	Excessive	Average Rating
Flight Plan Page	1	8		7.44	1	7	1	8.33
Waypoint Data Page		9		8.67		8	1	8.22
Present Position Page		8	1	9.0		8	1	8.89
Nav Aid Page	1	8		7.78		8	1	8.56
Nav Aid Data Page	1	7	1	7.78		7	2	8.67
Fuel Status Page	1	7	1	7.33		NA		
Emergency Data Page		NA				NA		
"Direct To" Function		8	1	8.0		9		8.56
Map		NA				NA		
Hold/Rendezvous		8	1	8.89	1	8		8.22
Takeoff and Landing Data	1	6	2	8.67	1	8		8.22
CG		8	1	8.56		9		8.0

Using Scale III, please rate the capabilities offered by the following special function pages of the nav management system - regardless of how you rated the quality of the information presented on those pages.

	MODERATE	MAJOR
Flight Plan Page	9.25	8.56
Waypoint Data Page	9.38	8.67
Present Position Page	9.5	8.67
Nav Aid Page	7.88	7.78
Nav Aid Data Page	8.13	7.44
Fuel Status Page	8.0	NA
Emergency Data Page	NA	NA
"Direct To" Function	8.75	7.44
Map	NA	NA
Hold/Rendezvous	8.88	8.22
Takeoff and Landing Data	7.75	6.67
C.G.	7.88	6.67

Overall, please rate the capabilities presented in this configuration for their usefulness/necessity in helping a 3-man crew accomplish the A/R mission: (Scale III)

MINIMUM: 8.11

MODERATE: 9.0

MAJOR: 7.89

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration?

MINIMUM		MODERATE		MAJOR	
Yes	4	Yes	7	Yes	7
No	5	No	2	No	2

Using Scale II, rate the workload level required of the copilot to monitor fuel flow and fuel quantity information during refueling:

MINIMUM: 3.1 MODERATE: 3.81 MAJOR: 5.0

Using Scale II, rate the workload level required of the copilot to relay fuel flow and fuel quantity information to the boom operator during refueling:

MINIMUM: 4.56

(Not applicable to moderate and major update)

The following questions apply to the mission segment and crew station configuration that you have just flown. Recognize that this is a mockup and you must imagine how it would actually be.

What percentage of your total workload came from each of the following areas:

	MINIMUM	MODERATE	MAJOR
Navigation tasks	26.11 %	22.22 %	31.67 %
Communications tasks	20.0 %	21.11 %	18.33 %
Piloting tasks	30.0 %	33.89 %	31.67 %
Aerial refueling tasks	12.22 %	14.44 %	9.22 %
Paperwork tasks	5.0 %	3.56 %	4.44 %
Other tasks	5.71 %	4.78 %	6.0 %

Rate your required workload level to accomplish the following: (Scale II)

	MINIMUM	MODERATE	MAJOR
Navigation tasks	6.83	6.0	6.11
Communication tasks	5.94	5.33	5.0
Piloting tasks	5.67	5.44	5.33
Aerial refueling tasks	5.33	4.89	4.67
Paperwork tasks	3.0	2.33	2.33
Other tasks	1.0	3.0	2.5
Overall level required to fly this configuration and mission	6.89	6.22	6.44
Overall level required by the other pilot to fly this configuration and mission	7.5	7.22	6.78

Rate your workload for the previous mission segment for each flight segment: (Scale II)

	MINIMUM	MODERATE	MAJOR
Departure	6.33	6.0	6.11
Climb	5.44	4.78	5.0
Cruise	5.11	4.33	5.11
Aerial Refueling	6.56	6.0	5.78
Descent	6.63	6.0	5.0
Approach and Landing	7.0	6.38	6.22

For the previous mission segment and cockpit configuration, please check which tasks were so difficult to accomplish as to pose a problem:

MINIMUM	MODERATE	MAJOR	
0	0	0	aircraft and engine systems monitors and control during normal operations
3	0	1	aircraft and engine systems monitors and control during emergency conditions
5	0	1	radar
1	4	2	fuel management
3	1	0	overall systems monitoring
3	2	4	see and avoid
3	2	1	terminal approaches
3	3	2	checklists
3	1	1	record keeping

With the 3-man crew, in the case of incapacitation of one pilot, could the mission still have been performed?

	MINIMUM	MODERATE	MAJOR
Yes	3	6	7
No	6	3	2

Could the aircraft have been flown home safely?

	MINIMUM	MODERATE	MAJOR
Yes	8	9	9
No	0	0	0

1 - Undecided

Now, imagine the previous segment being flown by a 2-man flight deck crew. In the case of incapacitation of one pilot, could the mission still have been performed?

	MINIMUM	MODERATE	MAJOR
Yes	2	3	3
No	7	6	6

Could the aircraft have been flown home safely?

	MINIMUM	MODERATE	MAJOR
Yes	7	8	7
No	1	1	2

1 - Undecided

With the 3-man crew, what do you think would be the optimal division of labor for the pilot, copilot, and boom operator?

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Reading checklists		3	2	3	1	*	4	2	2			4		3	2
Launch message		1		8		*			8			1		8	
Flight Planning		1		8		*		8				1	8		
Inputting flight plan into nav management system		N	A			*	3	4	1			5	4		
Monitoring PPSN and progress		5	4			*	5	2	1		1	5	3		
Departure briefings	4		5			*7		1			6		3		
Approach briefings	4		5			*6		2			6		3		
A/R fuel control		3	5			*	8				1	6		2	
Tuning comm radios		4	5			*	2	6				4	4	1	
Tuning nav radios		2	7			*	3	5				3	6		
Comm with ATC	1	6	2			*1	5	2			2	5	2		

* 1 - No Response

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Comm with cell formation	9					*7		1			8		1		
Comm with command post	6			2	1	*3			5		5			4	
Rendezvous comm	6	2		1		*6	1		1		7	2			
Copy coded messages				9		*			8					9	
Aircraft systems operations			8	1		*		8				1	8		
Rendezvous navigation	1	4	4			*1	2	5			3	2	4		
Weather radar	2	4	3			*1	1	6			1	2	6		
Ground mapping radar		6	3			*2	1	5				4	5		
Rendezvous radar	2	5	1	1		*2	2	4			4	3	2		
Monitoring engine instruments and caution/warning indicators			9			*1		6	1		2	1	6		
Fuel management		2	5	1	1	+	2	2	2	1		3	3	3	
Monitoring flight instruments	3		6			+3		4			4		5		

* 1 - No Response

\+ 2 - No Response

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Outside watch			7	1	1	+		5	1	1	2		5	1	1
Airborne radar approach (fly)	8	1				+6		1			8		1		
Airborne radar approach (direct)		9				+	6	1			1	7	1		
Map position monitor		2	5	1	1	+2	3	1	1		1	4	3	1	
AFTO Form 781	2		1	6		+		2	5		1		2	6	
Weight and balance				9		+			7					9	
Flight log				9		+			7			1	1	7	
T/O, landing data	1	5	3			+	3	3	1			4	2	3	
Determining enroute power settings	3	2	3	2		+1	1	3	2		2	3	2	2	
Aircraft control: Takeoff	6		3			+4		3			8		1		
Enroute	6		3			+4		3			6		3		
Approach	5		4			+2		5			6		3		
Landing	6		3			+3		4			6		3		
Crew coordination and command	8		1			+7					8		1		

42 - No Response

Using Scale I, rate the location of:

	MINIMUM	MODERATE	MAJOR
a) the navigation displays	7.22	8.88	8.67
b) the navigation equipment	7.19	7.88	8.44
c) the communication equipment	6.28	8.25	7.89
d) the aircraft systems controls and displays	6.67	8.38	8.22
e) the fuel control panel	6.89	6.75	7.56
f) aircraft systems annunciator lights	6.89	8.13	8.0
g) the radar controls	5.78	7.75	7.89
h) IFF/SIF	7.22	8.0	8.22

When transfer fuel flow rate and totalizer, aerial refueling pump switches, and aircraft fuel totalizer were provided to the boom operator at the boom station, was refueling workload significantly reduced for you?

MODERATE		MAJOR	
Yes	3	Yes	2
No	6	No	7

Using Scale III, please rate how much of a requirement exists for these boom station control/displays for 3-man operations:

MODERATE: 4.43 MAJOR: 5.38

COPILOT DESIGN EVALUATION RESULTS

MINIMUM

Compared to current tanker operations, rate how pilot/copilot workload would be affected if the navigator was replaced with dual INS integrated with the flight director and HSI, the boom operator was given more/upgraded responsibilities, and the present KC-135 individual control and display units were generally left intact (much like the configuration you just flew):

MODERATE

Rate how pilot/copilot workload would be affected if the KC-135 dedicated navigation controls and display units were replaced by a nav management system as conceptualized in the previous configuration:

MAJOR

Rate how pilot/copilot workload would be affected if the present KC-135 individual control and display units were replaced by an integrated communication/navigation radio frequency tuner:

0	1	2	3	4	5	6	7	8	9	10
Greatly increased		Moderately increased		Slightly increased	No change	Slightly decreased		Moderately decreased		Greatly decreased

MINIMUM: 2.11

MODERATE: 4.56

MAJOR: 4.67

Please rate the quality of the information presented on the following displays: (Scale I)

MINIMUM	MODERATE	MAJOR	
6.67	9.0	8.56	Navigation displays
6.56	8.5	8.67	A/C engine and system instrumentation
6.89	6.78	7.67	Fuel management controls/displays
5.78	8.44	8.67	Caution/warning system
6.22	8.22	7.38	A/C subsystems control indicators
NA	8.89	8.78	Nav mgt system control/display units
NA	7.33	8.33	Energy management (EPR command)
NA	NA	7.56	Integrated comm/nav frequency tuners

Please rate the capabilities provided by the following systems/displays (this rating is independent of how you rated the quality of the information): (Scale III).

MINIMUM	MODERATE	MAJOR	
6.56	9.0	8.22	Navigation displays
6.44	7.33	7.78	A/C engine and system instrumentation
6.44	6.56	6.89	Fuel management controls/displays
5.44	8.33	7.56	Caution/warning system
5.56	7.78	7.25	A/C subsystems control indicators
NA	9.11	8.33	Nav mgt system control/display units
NA	7.44	7.44	Energy management (EPR command)
NA	NA	6.11	Integrated comm/nav frequency tuners

Could the 3-man flight crew (upgraded boom operator) accomplish the preceding KC-135 mission:

	MINIMUM		MODERATE		MAJOR	
	Yes	No	Yes	No	Yes	No
With all avionics operational?	8	1	9	0	9	0
Without the autopilot, but with all other avionics operational?	7	2	8	1	9	0
Without the dual INS, but with all other avionics operational?	2	7	NA		NA	
Without the autopilot and dual INS, but with all other avionics operational?	2	7	NA		NA	
Without the nav mgt system but with all other avionics operational?	NA		3	6	5	4
Without the autopilot and nav mgt system but with all other avionics operational?	NA		1	8	Omitted	
Without the integrated comm/nav frequency tuners but with all other avionics operational?	NA		NA		9	0
Without the control/display unit for fuel mgt, CG, checklists and takeoff and landing data but with all other avionics operational?	NA		NA		9	0
Without the upgraded boom station?	NA		7	2	7	2

Could a 2-man flight deck crew (without boom operator assistance) accomplish the preceding KC-135 mission:

	MINIMUM		MODERATE		MAJOR	
	Yes	No	Yes	No	Yes	No
With all avionics operational?	6	3	8	1	8	1
Without the autopilot, but with all other avionics operational?	5	4	6	3	6	3
Without the dual INS, but with all other avionics operational?	0	9	NA		NA	
Without the autopilot and dual INS, but with all other avionics operational?	0	9	NA		NA	
Without the nav mgt system but with all other avionics operational?	NA		1	8	3	6
Without the autopilot and nav mgt system but with all other avionics operational?	NA		1	8	(Omitted)	
Without the integrated comm/nav frequency tuners but with all other avionics operational?	NA		NA		7	2
Without the control/display unit for fuel management, CG, checklists and takeoff and landing data but with all other avionics operational?	NA		NA		4	5
Without the upgraded boom station?	NA		5	4	5	4

Using Scale I, please rate the quality of the information contained on the following special function pages of the nav management system. In addition, please put your rating into what you feel to be the most appropriate "Information Amount" column.

	MODERATE Information Amount				MAJOR Information Amount			
	Insufficient	Sufficient	Excessive	Average Rating	Insufficient	Sufficient	Excessive	Average Rating
Flight Plan Page	1	8		8.33		9		7.89
Waypoint Data Page		9		8.22		9		8.22
Present Position Page		8	1	8.89		8	1	8.56
Nav Aid Page	1	8		8.67		9		8.22
Nav Aid Data Page	2	7		8.56	*1	7		8.0
Fuel Status Page	1	8		8.0		NA		
Emergency Data Page		NA				NA		
"Direct To" Function	*	8		8.75		9		8.44
Map		NA				NA		
Hold/Rendezvous	*	8		8.63	2	7		8.89
Takeoff and Landing Data		9		9.0		8	1	8.67
CG		9		7.89		8	1	8.0

*1 - No Response

Using Scale III, please rate the capabilities offered by the following special function pages of the nav management system - regardless of how you rated the quality of the information presented on those pages.

	MODERATE	MAJOR
Flight Plan Page	8.89	9.11
Waypoint Data Page	8.89	8.56
Present Position Page	9.0	8.67
Nav Aid Page	8.22	7.67
Nav Aid Data Page	8.0	7.56
Fuel Status Page	7.22	NA
Emergency Data Page	NA	NA
"Direct To" Function	8.5	8.33
Map	NA	NA
Hold/Rendezvous	8.56	8.67
Takeoff and Landing Data	8.11	7.33
C.G.	6.78	7.0

Overall, please rate the capabilities presented in this configuration for their usefulness/necessity in helping a 3-man crew accomplish the A/R mission: (Scale III)

MINIMUM: 7.25

MODERATE: 8.89

MAJOR: 9.11

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration?

MINIMUM		MODERATE		MAJOR	
Yes	6	Yes	7	Yes	7
No	3	No	2	No	2

Using Scale II, rate the workload level required of the copilot to monitor fuel flow and fuel quantity information during refueling:

MINIMUM: 6.11 MODERATE: 4.89 MAJOR: 3.38

Using Scale II, rate the workload level required of the copilot to relay fuel flow and fuel quantity information to the boom operator during refueling:

MINIMUM: 4.67

(Not applicable to moderate and major update)

The following questions apply to the mission segment and crew station configuration that you have just flown. Recognize that this is a mockup and you must imagine how it would actually be.

What percentage of your total workload came from each of the following areas:

	MINIMUM	MODERATE	MAJOR
Navigation tasks	40.0 %	35.0 %	35.0 %
Communications tasks	22.78 %	29.0 %	26.11%
Piloting tasks	9.06 %	13.89 %	12.89%
Aerial refueling tasks	14.11 %	11.0 %	11.89%
Paperwork tasks	9.0 %	6.56 %	9.0 %
Other tasks	6.78 %	5.67 %	4.56%

Rate your required workload level to accomplish the following: (Scale II)

	MINIMUM	MODERATE	MAJOR
Navigation tasks	7.22	6.44	6.28
Communication tasks	5.44	5.56	5.67
Piloting tasks	3.78	3.33	3.89
Aerial refueling tasks	4.67	4.44	4.0
Paperwork tasks	3.88	3.78	3.56
Other tasks	-	3.88	3.38
Overall level required to fly this configuration and mission	7.0	5.89	6.11
Overall level required by the other pilot to fly this configuration and mission	6.44	5.44	6.11

Rate your workload for the previous mission segment for each flight segment: (Scale II)

	MINIMUM	MODERATE	MAJOR
Departure	5.89	5.78	5.56
Climb	5.11	5.0	5.44
Cruise	4.0	3.44	4.44
Aerial Refueling	6.22	4.89	5.22
Descent	6.78	5.88	5.78
Approach and Landing	7.44	6.5	6.67

For the previous mission segment and cockpit configuration, please check which tasks were so difficult to accomplish as to pose a problem:

MINIMUM	MODERATE	MAJOR	
0	0	0	aircraft and engine systems monitors and control during normal operations
2	0	1	aircraft and engine systems monitors and control during emergency conditions
3	1	0	radar
2	2	1	fuel management
2	0	0	overall systems monitoring
4	4	4	see and avoid
1	1	1	terminal approaches
2	2	3	checklists
1	1	0	record keeping

With the 3-man crew, in the case of incapacitation of one pilot, could the mission still have been performed?

MINIMUM		MODERATE		MAJOR	
Yes	5	Yes	5	Yes	7
No	4	No	4	No	2

Could the aircraft have been flown home safely?

MINIMUM		MODERATE		MAJOR	
Yes	9	Yes	9	Yes	9
No	0	No	0	No	0

Now, imagine the previous segment being flown by a 2-man flight deck crew. In the case of incapacitation of one pilot, could the mission still have been performed?

MINIMUM		MODERATE		MAJOR	
Yes	2	Yes	3	Yes	5
No	7	No	6	No	4

Could the aircraft have been flown home safely?

MINIMUM		MODERATE		MAJOR	
Yes	7	Yes	8	Yes	9
No	2	No	1	No	0

With the 3-man crew, what do you think would be the optimal division of labor for the pilot, copilot, and boom operator?

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Reading checklists		3		6	3		3		6			2		7	
Launch message				9			1		8					9	
Flight Planning	1		7		1	1		7		1			9		
Inputting flight plan into nav management system			NA			1	2	5	1			4	4		1
Monitoring PPSN and progress		4	1	2	2		4	3		2		7	2		
Departure briefings	5		4			4		5			6		3		
Approach briefings	4		5			4		5			6		3		
A/R fuel control		7	1		1		5	1	2	1	1	4	1	3	
Tuning comm radios		4	1	3	1		3	2	3	1		3	2	4	
Tuning nav radios		5	1	2	1		3	4	1	1		3	3	3	
Comm with ATC	1	5	2	1		1	5	1	1	1		6	2	1	

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Comm with cell formation	9					9					8		1		
Comm with command post	1			7	1	3			6		1			7	1
Rendezvous comm	5	3	1			5	3	1			5	2	2		
Copy coded messages				9				1	8					8	1
Aircraft systems operations		4	4		1		2	6		1		2	7		
Rendezvous navigation	1	4	4			2	4	3			1	6	2		
Weather radar	1	3	5			4	2	2		1	2	3	3	1	
Ground mapping radar		5	3	1			5	4				5	4		
Rendezvous radar	1	6	2			3	3	3			1	5	3		
Monitoring engine instruments and caution/warning indicators	1	2	4	1	1			7	1	1			7	1	1
Fuel management	1	5	1	1	1	+	3	3	1			2	3	4	
Monitoring flight instruments	2		6		1	+1		6			1	1	7		

+2 - No Response

	MINIMUM					MODERATE					MAJOR				
	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal	Predominantly Pilot	Predominantly Copilot	Both Pilots Equal	Predominantly Boom Operator	All 3 Crew-members Equal
Outside watch	1	1	6			+		5		2			5	2	2
Airborne radar approach (fly)	8		1			+6		1			8		1		
Airborne radar approach (direct)		7	1	1		+	6	1				8	1		
Map position monitor		5		3	1	+	3	2	1	1		4	4	1	
AFTO Form 781	1		1	7		+2			5		2			7	
Weight and balance				9		+			7					9	
Flight log		3		6		+	1		6			2		7	
T/O, landing data		5	2	2		+	2	1	4			3	1	5	
Determining enroute power settings	2	5	1			+1	3	2	1		1	2	2	4	
Aircraft control: Takeoff	6		3			+4	1	2			7		2		
Enroute	5		4			+3	1	3			5		4		
Approach	5		4			+4	1	2			6		3		
Landing	6		3			+4	1	2			6		3		
Crew coordination and command	8		1			+6		1			8		1		

+2 - No Response

Using Scale I, rate the location of:

	MINIMUM	MODERATE	MAJOR
a) the navigation displays	7.75	8.0	8.11
b) the navigation equipment	6.11	7.78	7.0
c) the communication equipment	6.38	6.67	7.11
d) the aircraft systems controls and displays	6.63	7.11	7.56
e) the fuel control panel	7.5	6.44	7.22
f) aircraft systems annunciator lights	7.25	8.11	8.44
g) the radar controls	5.89	6.33	7.56
h) IFF/SIF	6.67	7.56	6.89

When transfer fuel flow rate and totalizer, aerial refueling pump switches, and aircraft fuel totalizer were provided to the boom operator at the boom station, was refueling workload significantly reduced for you?

MODERATE		MAJOR	
Yes	6	Yes	6
No	3	No	3

Using Scale III, please rate how much of a requirement exists for these boom station control/displays for 3-man operations:

MODERATE: 6.75 MAJOR: 6.38

BOOM OPERATOR

DESIGN EVALUATION RESULTS

Assuming that you would be performing inflight monitoring duties, please rate the location of: (Scale I)

	MINIMUM	MODERATE	MAJOR
a) the navigation displays:	7.56	7.0	7.0
b) the navigation equipment:	7.67	6.89	7.11
c) the communication equipment:	6.38	6.67	7.0
d) the aircraft systems controls and displays:	7.25	7.67	7.56
e) the fuel control panel:	7.88	7.0	8.0
f) the fuel quantity indicators:	7.63	6.56	8.22
g) the aircraft systems annunciator lights:	7.13	7.33	7.78
h) the radar controls:	.25	7.38	7.33

Was it necessary to have both the center console area and the 3rd nav station accessible to the boom operator?

MINIMUM	MODERATE	MAJOR
Yes: 7	Yes: -	Yes: -
No: 2	No: -	No: 2

Assuming that the seat was on an "L" shaped track, did you like the way the jump seat maneuvered between two crew stations?

MINIMUM	MODERATE	MAJOR
Yes: 8	Yes: 7	Yes: 8
No: 1	No: 1	No: 1

1 - Undecided

Do you feel you had sufficient time to perform "see and avoid" duties while performing other designated tasks?

MINIMUM	MODERATE	MAJOR
Yes: 6	Yes: 7	Yes: 7
No: 3	No: 1	No: 1

1 - Undecided

Using Scale III, please rate the capabilities presented in this overall cockpit and boom station design to accomplish the A/R mission with a 3-man crew:

MINIMUM: 6.5

MODERATE: 7.88

MAJOR: 7.17

The following questions apply to the mission interval you have just flown.

What percentage of your total workload came from each of the following areas:

	MINIMUM	MODERATE	MAJOR
Navigation tasks	10.78 %	6.67 %	15.0 %
Communication tasks	16.44 %	15.44 %	17.22 %
Aerial refueling tasks	37.78 %	40.56 %	37.78 %
Paperwork tasks	16.11 %	12.11 %	9.56 %
Fuel management	3.33 %	4.0 %	3.89 %
Weight and balance	4.78 %	3.44 %	4.11 %
See and avoid	6.56 %	6.33 %	4.0 %
Free time	3.56 %	3.33 %	1.56 %
Other (not listed above)	1.0 %	6.78 %	5.78 %

Using Scale II, please rate your required workload level to accomplish the following during the last mission interval:

	MINIMUM	MODERATE	MAJOR
Navigation tasks	5.5	3.89	4.67
Communications tasks	5.44	5.56	5.67
Aerial refueling tasks	6.94	7.22	6.22
Paperwork tasks	5.56	4.56	4.89
Fuel management	2.88	3.11	3.56
Weight and balance	2.89	3.33	3.11
See and avoid	3.63	3.56	2.89
Free time	2.38	2.13	2.13
Other (not listed above)	-	-	-

In your opinion, can a 2 pilot/1 boom operator crew safely and adequately perform a mission similar to the one just flown with that same equipment?

MINIMUM	MODERATE	MAJOR
Yes: 5	Yes: 8	Yes: 9
No: 3	No: 1	No: 0

1 - Undecided

When transfer fuel flow rate and totalizer, aerial refueling pump switches and aircraft fuel totalizer were provided to you at the boom station, did you:

	MODERATE	MAJOR
a) Feel your workload was:		
increased?	7	8
decreased?	0	0
stayed the same?	2	1
b) Feel that safety was:		
enhanced?	1	1
not affected?	3	3
jeopardized?	5	5
c) Feel that aerial refueling procedures were:		
more simplified?	2	2
more complicated?	6	6
not affected?	1	1

Using Scale III, please rate how much of a requirement exists for these extra boom station controls/displays in 3-man (pilot, copilot, boom operator) operations:

MODERATE: 5.0

MAJOR: 5.64

Using Scale I, please rate the quality of the layout of the boom station:

MODERATE: 6.71

MAJOR: 5.63

Using Scale III, please rate the capabilities provided by having weight and balance calculations computerized:

MODERATE: 7.22

MAJOR: 8.25

Using Scale III, please rate the capabilities provided by having takeoff and landing data calculations computerized:

MODERATE: 7.89

MAJOR: 8.75

MAJOR ONLY:

Using Scale III, please rate the capabilities provided by having automatic/programmable fuel management:

RATING: 7.63

Using Scale III, please rate the capabilities provided by having checklists on a CRT (as opposed to the conventional binder):

5.89 Normal checklists

7.0 Emergency checklists

PILOT POST-MOCKUP DATA

With no navigator, if the boom operator flight deck duties and responsibilities were expanded, how valuable would his assistance be with the following tasks? (Check only one column for each item)

	Not Useful	Slightly Useful	Moderately Useful	Extremely Useful	Required
Reading checklists	1	2	2	2	2
Enroute radio monitoring & communication			5	3	1
Rz communication	4	4	1		
A/C systems monitoring		2	3	3	1
Navigation	1	2	4	2	
See and avoid		2	2	2	3
Adjusting power controls	6	3			
Fuel monitor		1	2	4	2
Fuel management		1	3	3	2
Weight and balance		1	1	3	4
Preflight tasks		3	3	1	2
Troubleshooting malfunctions			6	1	2
Inflight maintenance	1	2	1	3	2
Emergency backup in case of one pilot incapacitation		1	3	1	4
Copy and decode messages			1	3	5
Map position recording			1	5	3

Using Scale III, rate the requirement to have a "Boom Engaged" light or indicator on the copilot's side in addition to the one on the pilot's side: 4.56

What communication equipment is required/desired for accomplishment of the KC-135 mission? (Fill in the number of each that you feel are needed)

No. Required		No. Desired	
2	UHF	2	UHF
1	VHF	1	VHF
1	HF	1	HF
0	FM	0	FM
0	SELCAL	1	SELCAL

What navigation equipment is required/desired for accomplishment of the KC-135 mission? (Fill in the number of each that you feel are needed).

No. Required		No. Desired
1	Doppler	1
2	INS	2
1	RNAV	5 Pilots - 1 4 Pilots - 2
4 Pilots - 1 5 Pilots - 2	VOR	2
1	TACAN	2
1	ADF	1
2	ILS	2
1	MLS	2 Pilots - 1 3 Pilots - 2
1	Ground Mapping Radar	1
0	Sextant	0

Using Scale III, please rate the requirement for an accelerometer ("G" meter) information display to accomplish the KC-135 mission: 2.67

Using Scale III, please rate the requirement for selectable digital readout capability on engine instruments and subsystems pressures and quantities in addition to scale readouts: 6.33

Which do you feel is the minimum avionics update level required to perform the KC-135 mission? (Check one item for 2-man and one item for 3-man).

	With a 2-man flight deck crew	With a 3-man (2 pilot, upgraded boom operator) flight deck crew
Dedicated controls/displays (present KC-135) plus INS	1	3
Integrate all nav functions into one control/display	4	4
Integrate all comm functions into one control/display	0	0
Integrate both comm and nav functions into respective control/display units	4	2

Using Scale III, please rate the requirement for all annunciations to be on a CRT with a computerized priority listing: 4.44

Using Scale III, please rate the requirement for having emergency checklists integrated with the annunciator panel and automatically displayed on a CRT: 4.89

Please indicate your 1st, 2nd, and 3rd choice for the caution/warning system you would like to see on the KC-135:

Choice	
1 - 2nd 4 - 3rd	Conventional system as it is now (Scattered caution/warning indicators)
6 - 1st 2 - 2nd 3 - 1st	Fully centralized annunciator panel (Caution/warning indicators on one panel)
2 - 2nd 1 - 3rd	Digital alphanumeric readout with a prioritized listing

Which systems should be computer programmable (please list, i.e. C.G., TOLD, fuel management, checklists, nav aid tuning)?

See Comments Section

Which systems should be completely automated (Please list, i.e. fuel management, checklists, approach/landing computations)?

See Comments Section

Using Scale III, please rate the requirement for an HSD vs. an HSI: 9.56

Using Scale III, please rate the requirement for the following HSD information:

8.89 Symbol generated map

9.67 Wx radar

9.22 HSI

9.56 Ground mapping radar

9.67 Beacon

Using Scale III, please rate the requirement for the following HSD information overlays:

9.44 Map with wx

8.22 Map with beacon

9.0 Map with ground map

Using Scale III, please rate the requirement for a color HSD as opposed to black and white HSD: 6.11

MOCKUP EVALUATION

How realistic was the mockup experience? (check one)

_____ a). Just like real life; you could easily image being in an actual flight.

__3__ b). A close approximation; you could image being in an actual flight, but you were always aware of the artificiality of the situation.

__3__ c). Similar to a real experience; you had some difficulty imagining yourself in an actual flight.

__3__ d). Although unreal, it aided in role playing and, therefore, enhanced the realism of the flight.

_____ e). Barely similar to a real experience; you had great difficulty imagining yourself in an actual flight.

_____ f). Completely unlike real life experience; you could never imagine being in an actual flight.

How did the unrealistic aspects of the mockup influence your answers on the questionnaire? Were you most likely to underestimate or overestimate the difficulty of the following tasks?

	Overestimate	Underestimate	Neither
Communication tasks	2	3	4
Navigation tasks	5	4	
Piloting tasks		5	4
A/R tasks		3	6
Rz tasks		8	1
Other tasks		3	4

How representative of a tanker mission was the mission scenario?

__4__ a). an excellent representation

__4__ b). a good approximation

__1__ c). a fair approximation

_____ d). a poor approximation

_____ e). a very bad approximation

COPILOT POST-MOCKUP DATA

With no navigator, if the boom operator flight deck duties and responsibilities were expanded, how valuable would his assistance be with the following tasks? (Check only one column for each item)

	Not Useful	Slightly Useful	Moderately Useful	Extremely Useful	Required
Reading checklists		1	3	5	
Enroute radio monitoring & communication		1	2	5	1
Rz communication	2	5	2		
A/C systems monitoring		1	5	3	
Navigation	1	2	4	2	
See and avoid		1	3	2	3
Adjusting power controls	6	2	1		
Fuel monitor	1		3	4	1
Fuel management	2		4	2	1
Weight and balance			1	4	4
Preflight tasks	1	1		3	4
Troubleshooting malfunctions	1		4	2	2
Inflight maintenance	1	1	1	4	2
Emergency backup in case of one pilot incapacitation	1	3	2	1	2
Copy and decode messages			1	2	6
Map position recording		1	2	5	1

Using Scale III, rate the requirement to have a "Boom Engaged" light or indicator on the copilot's side in addition to the one on the pilot's side: 4.67

What communication equipment is required/desired for accomplishment of the KC-135 mission? (Fill in the number of each that you feel are needed)

No. Required		No. Desired
2	UHF	2 4 Copilots -1
1	VHF	5 Copilots -2
1	HF	1
2 Copilots -1; 3 Copilots -2	FM	3 Copilots -0 2 Copilots -1
3 Copilots -0; 3 Copilots -1	SELCAL	1

What navigation equipment is required/desired for accomplishment of the KC-135 mission? (Fill in the number of each that you feel are needed).

No. Required		No. Desired
1	Doppler	1
2	INS	2
1	RNAV	1
2	VOR	2
4 Copilots -1 5 Copilots -2	TACAN	2
1	ADF	1
2	ILS	2
1	MLS	2 Copilots -1 2 Copilots -2
1	Ground Mapping Radar	1
3 Copilots -0 4 Copilots -1	Sextant	3 Copilots -0 3 Copilots -1

Using Scale III, please rate the requirement for an accelerometer ("G" meter) information display to accomplish the KC-135 mission: 1.44

Using Scale III, please rate the requirement for selectable digital readout capability on engine instruments and subsystems pressures and quantities in addition to scale readouts: 7.44

Which do you feel is the minimum avionics update level required to perform the KC-135 mission? (Check one item for 2-man and one item for 3-man).

	With a 2-man flight deck crew	With a 3-man (2 pilot, upgraded boom operator) flight deck crew
Dedicated controls/displays (present KC-135) plus INS	0	1
Integrate all nav functions into one control/display	3	6
Integrate all comm functions into one control/display	0	0
Integrate both comm and nav functions into respective control/display units	5	2

1 copilot: no response

Using Scale III, please rate the requirement for all annunciations to be on a CRT with a computerized priority listing: 6.56

Using Scale III, please rate the requirement for having emergency checklists integrated with the annunciator panel and automatically displayed on a CRT: 5.33

Please indicate your 1st, 2nd, and 3rd choice for the caution/warning system you would like to see on the KC-135:

Choice

7 - 3rd Conventional system as it is now (Scattered caution/warning indicators)

5 - 1st
4 - 2nd Fully centralized annunciator panel (Caution/warning indicators on one panel)

4 - 1st
3 - 2nd Digital alphanumeric readout with a prioritized listing

Which systems should be computer programmable (please list, i.e. C.G., TOLD, fuel management, checklists, nav aid tuning)?

See Comments Section

Which systems should be completely automated (Please list, i.e. fuel management, checklists, approach/landing computations)?

See Comments Section

Using Scale III, please rate the requirement for an HSD vs. an HSI: 8.22

Using Scale III, please rate the requirement for the following HSD information:

8.33 Symbol generated map

8.78 Wx radar

8.89 HSI

9.0 Ground mapping radar

9.0 Beacon

Using Scale III, please rate the requirement for the following HSD information overlays:

9.0 Map with wx

8.56 Map with beacon

7.67 Map with ground map

Using Scale III, please rate the requirement for a color HSD as opposed to black and white HSD: 6.67

MOCKUP EVALUATION

How realistic was the mockup experience? (check one)

_____ a). Just like real life; you could easily image being in an actual flight.

__2__ b). A close approximation; you could image being in an actual flight, but you were always aware of the artificiality of the situation.

__*3__ c). Similar to a real experience; you had some difficulty imagining yourself in an actual flight.

__*4__ d). Although unreal, it aided in role playing and, therefore, enhanced the realism of the flight.

_____ e). Barely similar to a real experience; you had great difficulty imagining yourself in an actual flight.

__1__ f). Completely unlike real life experience; you could never imagine being in an actual flight.

* One copilot checked both of these items

How did the unrealistic aspects of the mockup influence your answers on the questionnaire? Were you most likely to underestimate or overestimate the difficulty of the following tasks?

	Overestimate	Underestimate	Neither
Communication tasks	4	3	2
Navigation tasks	1	5	2
Piloting tasks		5	4
A/R tasks	1	3	5
Rz tasks	1	7	1
Other tasks		4	3

How representative of a tanker mission was the mission scenario?

__3__ a). an excellent representation

__5__ b). a good approximation

__1__ c). a fair approximation

_____ d). a poor approximation

_____ e). a very bad approximation

Section C

Subject Comments from the Mockup Questionnaires and Debriefing Sessions

PILOT/COPILOT QUESTIONNAIRE

PRE-MOCKUP

Estimate the % of your missions when a mission change is received after departure to require refueling at a different location than that planned before launch.

Comments:

P1 +5%. Few changes are made in the actual track location. Most changes involve timing changes, i.e. late take-off or late receivers.

CP1 5%. Most mission changes are made prior to preflight with most paperwork accomplished at base operations.

P2 20%. Many times late receivers, who have suffered maintenance delays, require changes to the refueling plan, i.e. change in track or change in offload.

CP2 10%. Many other missions will refuel at the same place as planned, but at radically different times.

P3 3-5%. Most changes involve ARCT (timing) and number of receivers.

CP3 5 or less %. However, about 25% of the time our receivers are changed, and the time for refueling is also changed but usually refuel same location. Now the sequence of events is juggled, instead of air refuel and nav leg, now it's nav leg and A/R.

CP4 2%. The A/R track rarely changes. However, time delays and cancellation of the track happen quite often.

P5 10%. Most all of our refuelings state side involve the SR-71. Very seldom is the A/R track changed after we are airborne. I can never remember of this happening with the SR-71. However, in Europe this does happen. I would say 10%, maybe 15% of the time.

CP5 20%. Most of our SR-71 missions are time changed due to late takeoff, or involve moving the ARCP due to weather.

P8 1%. Extremely rare.

CP8 .5%. Seldom change refueling areas, but frequently change operations within the planned area, primarily due to weather factors.

P9 10%. Approximatel 50-60% of missions change to add or delete refuelings, or to change ARCT considerably. But refuelings generally take place in same location.

CP9 10%. Usually when there is a change at our base, the crew will fly a nav leg first and then go to the original ARCP for a refueling, instead of the refueling first.

Estimate the number of times you have accomplished an airborne radar-directed approach when the ceiling/visibility was within 1000 feet and 1 mile of published non-precision minima.

Comments:

P1 None. We only fly 4 ARDA per year and our required weather must be VFR from FAF inbound which means wx ceiling not less than 500' above the FAF altitude.

CP1 0. Due to weather requirements to fly an ARDA, one rarely finds himself in any weather as described above.

P2 None. The ARDA is a quarterly requirement and is usually accomplished with good weather minimums.

P3 6. Have always had VFR conditions from final approach fix inbound - however, when flying a typical non-precision approach this would still have been below 1000/1 at times.

CP4 None. Current directives prohibit us from flying ARDAs with less than VFR from final approach fix.

P5 0 to 1. Very seldom do we do these if the weather is significant at all. Most of the ARAs that I can recall doing were accomplished during VFR comditions.

P6 Average 1-2 approaches per month, but we are not permitted to fly the approach unless the weather is VFR from the FAF inbound. FAF is approximately 1300' above minimums.

CP6 None. Used very seldom/only for navigator training.

P7 0. Used only as a backup to the pilots.

P8 3. All three on one flight.

P9 0. SAC requires VFR conditions from final approach fix inbound.

Estimate the number of out of country (USA) tanker deployments you have had and the total number of months spent on tanker deployments.

Out of country number of deployments
Total number months on tanker deployments

Comments:

P1 One, 35 days. This was one trip to Mildenhall TTF to include Spain, Germany, Iran, Turkey.

CP1 1, 3 days. 3 day deployment→Canal Zone

P2 6, 2 months. Many of the deployments were start 4-10 day deployments from the west coast to Hawaii or from the east coast to Europe.

P3 10, 13. This includes 3 to Utapao AB (Young Tiger), 3 to Torrejon/ Mildenhall (European TTF), and others from Pease to Mildenhall and March → Hickam-Wake as well as one to South America.

P5 16, 16. 3 to 4 times a year we are tasked to deploy either to Mildenhall AB or Kadina AB; 30 days is the duration of most of these TDYs.

CP5 15, 15. We deploy TDY to England or Japan once every three months for 30 days.

CP6 2, 3 months. Guam/U.K.

CP8 12, 11. Includes 187 days TDY for ARC LIGHT at Okinawa.

P9 3, 4. Guam/Thailand, Spain, England.

CP9 6, 3. One month was in the Pacific (Guam), two months at Mildenhall. VHF radios and a INS system would have made the trips less confusing.

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(a) How would you rate the present communications capabilities of the KC-135? (Scale I)

Please explain briefly:

P1 7. The new solid state UHFs are excellent. The HF radios are very often ↑40% not useable. There is a drastic need when operating in the European theater for VHF radios.

CP1 6. A new HF radio is needed and VHF capability would also improve operations.

P2 9. The addition of a VHF radio would compliment the present system.

CP2 7. HF radio is often unusable due to atmospheric interference.

P3 7. VHF capability would greatly improve operations - particularly overseas.

CP3 8. UHF is very nice with our new radios. VHF would be nice but not necessary (unless overseas). HF is and probably will always be poor.

P4 7. The new UHF radios and TACAN systems are excellent. The HF is fair but useable.

CP4 5. Needs dual TACAN, VHF and HF radios.

P5 4. I have never flown a mission that was not completed because of communication requirements. However, itwould be a lot easier, especially over water and in Europe and Asia, if we had a better HF and a VHF radio. Sometimes a copilot spends most of his time trying to communicate on the HF

CP5 7. HF communications are not very good. The lack of a VHF radio is a problem.

P6 8. It has a good backup system with 2 UHF and one HF,but it would be more efficient overseas if it also had a VHF radio.

CP6 5. HF radio has tremendous static problems. The radio is difficult to tune and malfunctions frequently. VHF radios would increase capabilities significantly.

P7 7. I served on the KC-135A from June 68 to Oct 70 in SEA and experienced no problems in communications.

CP7 9. I have not had any problem with either HF or VHF radios in the tank.

P8 5. UHF 9/HF 5/VHF 0/interphone 2 (worst problem on acft).

CP8 4. Rating given for the ZI, would be less overseas when working non-military facilities. Should have a dual VHF installation and better HF (possibly dual HF).

P9 3. HF radios simply do not operate consistently well enough to enable effective command control and inflight coordination overseas, especially during EWO scenario.

CP9 7. Need to have a VHF radio for better worldwide capabilities.

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(b) How would you rate the present navigation capabilities of the KC-135? (Scale I)

Please explain briefly:

P1 7. The new TACAN is very excellent, however, we need more reliable air to air bearing information than our ADF. The PINS is good for overwater but the pilot has no information readouts. The radar scope is virtually unuseable from the pilot's seat - especially during daylight. Celestial navigation is only as good as the user. There are many opportunities for errors in computations and in plotting.

CP1 4. The new TACAN greatly improved over land navigation capabilities.

P2 5. Overwater capabilities are limited. The use of doppler alone is a fair at best system when it works. Loran or INS would upgrade the system considerably.

CP2 5. In comparison to INS, and radar capabilities of bombers, the KC-135 is almost pre-historic.

P3 7. PINS fills a very real void in overwater capability. The present radar, doppler, etc. are minimum reliable in my opinion.

CP3 6-7. For in country pilot proficiency - good (esp. new TACAN). Seems only fair when it comes to depending completely on nav for overwater (unless INS used), i.e. low rating is for navigator's equipment not including the INS.

P4 5. In the CONUS they are excellent. However, overwater navigation can become very difficult and is based almost solely on the sextant.

CP4 3. Although that might be a bit pessimistic. The navigator - sextant routine is extremely limited, any time you leave the N.S. For flying airways, I would rate it a 6.

P5 5. Without "PINS" the accuracy of the tanker nav system does not qualify us to fly in a good many areas. I'm thinking of over water deployments now.

CP5 7. Most of the present stone age equipment seems to work 70% of the time.

P6 5. The navigation equipment is good when all systems are functioning properly. The problem is that the systems are not that reliable.

CP6 5. Need INS rather than a navigator on long transoceanic flights.

P7 7. I've never been lost.

CP7 7. Since we have the nav to navigate the pilots, navigation equipment is down played. But I've found it good enough for the simple navigation required as a pilot.

P8 5. Overland with VORTAC,7; overwater,3 (we do not have PINS); with PINS,5.

CP8 5. Rating would be higher for ground based aids only, but for the intended mission rating is lower. (Could use a good RNAV)

P9 4. Present systems do not provide sufficient accuracy overseas to carry out precise rendezvous.

CP9 7. INS system would be beneficial.

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(c) How would you rate the present piloting (aircraft maneuvering, airspeed control, see and avoid, mission control) and associated capabilities of the KC-135? (Scale I)

Please explain briefly:

P1 7. There is a need for better performing engines - especially on heavy take-offs. The pilots' seats are very uncomfortable due to their design for seldom used parachutes.

CP1 5. The aircraft is many times underpowered as compared to the heavier gross weights.

P2 7. I feel that the major drawback with the KC-135 is that it is underpowered. The Toott and Whiting J-57s are good reliable engines. However, the TF-33s would greatly enhance the mission capabilities of the aircraft. The addition of winglets will increase range and decrease fuel degradation.

CP2 7. Maneuverability is not good, but I wouldn't expect it to be for a large aircraft. The aircraft is slow to respond to control inputs. All other areas are good or better.

P3 9. The FD-109 is a superb system which has enhanced overall piloting capability.

CP3 6. Noise abatement procds require a high angle of climb which restricts pilots' abilities to see and avoid.

P4 7. It's a good flying airplane. However, it is underpowered for mission requirements in the area of takeoff rated thrust. It is also marginal from the aspect of see and avoid since most pilots use a continuous instrument crosscheck.

CP4 7. I would like to see a true airspeed indicator up front with GNO speed readout. True airspeed control hookup with autopilot.

P5 9. I haven't flown any other large aircraft.

CP5 9. Fan sets would improve safety by allowing the pilot to have more power available when needed.

P7 5. See and avoid is poor due to a constant need for inside cockpit reference.

CP7 7. In general I find the 135 easy to fly and control, however, airspeed control can be challenging when the throttles are not within a knob width or two of being aligned.

P8 Maneuvering, 7; A/S control, 4; See and Avoid, 1 (dependence on instruments, detracts from looking out); MSN control, 1 (this problem results from multiple acft talking simultaneously).

CP8 8. Visibility for see and avoid plus checklist duties lower the rating. Chart and paperwork storage is very poor.

P9 7. With present cockpit, pilots need true airspeed indicator up front. Also needs greater thrust available for runway/weather conditions and emergency breakaways.

CP9 7. Overall it's good, but see and avoid is a different story. I would rate 0. We are unable to pick up aircraft or if we are locked in as a target.

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(d) How would you rate the present aerial refueling and associated capabilities of the KC-135? (Scale I)

P1 9. There are not many problems with our present system.

P2 9. I consider the system a sound and capable system. There are certainly some improvements that can be made. A better boom with better aerodynamic design would help stabilization and cut down on fuel degradation (drag).

CP2 8. Very good at what it does, but limited quantity of fuel. Even an extra 20,000 pounds would be a great help for either EWO or overwater fighter drags.

CP3 8. Although limited in offload when it comes to the heavies (C-5, E-4, etc.)

P4 7. Usually reliable. But for present requirements more fuel per tanker would greatly alleviate some mission problems. Also with the necessity of the boom operator having to take his eyes off the receiver to look at gages will cause continuous incidents.

CP4 7. Would like to see a radar available to integrate IFF/SIF codes and modes, not only for A/R but also for see and avoid concept. Headup display for boom.

P5 8. Big problem I see is the size of the tanker. It's too small.

CP5 10. Excellent.

P6 9. Would be nice to have additional thrust capability during emergency separation.

CP6 7. Boom operator needs a HUD.

P7 7. At present I would estimate less than a 5% abort rate for A/R problems.

CP7 9. I have not encountered any problems in this area.

CP8 8. Boom operator visibility is poor for fighter operations.

P9 8. Needs more workable air conditioning system.

Capability is defined as the ability of the aircraft/hardware to perform all required tanker missions. With that in mind . . .

(e) How would you rate the present overall capabilities of the KC-135? (Scale I)

Comments:

P1 8. The tanker does a good job. It has proven itself many times. The systems, gauges, and engines are obviously outmoded.

CP1 6. To improve the mission capability, fans should be put on the KC-135.

P2 5. Once the INS is put on board, the re-skinning is complete, and new engines are added; then the aircraft will be either 9 or 10.

CP2 6. Not the best for cargo hauling, and passengers can really get uncomfortable as their numbers increase.

P3 7. The two largest deficiencies that I see are in thrust/weight ratio (particularly on large fighter deployment type operations and EWO) and basic navigational capability.

CP3 7. Although it needs more power - new engines

P4 6. Stress on the aircraft structure and the outdated power characteristics (necessity to use water injection) will be the limiting factors that either degrade or cancel a mission or lead to incidents in the future.

CP4 5. The most important improvement would be re-engine with fans with reversing engines.

CP5 9. Limited only by airframe restrictions and sometimes long takeoff rolls.

P6 7. It is capable but it would be enhanced by improved navigation and thrust capability.

CP6 6. With better comm/nav equipment,the 135 would rate a 9.

P7 5. All airframe systems need reworked. Airframe is tired and wore out.

CP7 7. I think the present capabilities are good, but some newer engines would make me feel better on hot days.

CP8 7. Navigation, communications and performance calculation limit the rating.

P9 6. Good airplane for its age.

CP9 7. As for the VHF radio and INS system is concerned, the aircraft is good.

Please rate the adequacy of the present KC-135 crew station lighting.
(Scale I) Day and Night

Any comments:

P1 9, 5. There is too much glare at night. The interphone panel is very difficult to read, especially on the newer interphone panels with individual push/pull volume controls.

CP2 8. 5. Nav station lights at night are often to bright and reflect forward. Copilot portable light is almost unusable for normal copilot duties at night (i.e. engine analysis, plotting of nav legs, etc.)

P2 9, 7. There is a minor lighting problem due to navigator station lighting. It doesn't present any real problem, though. The lights sometimes cause a reflection or glare on the windscreen. Overall the lighting is good when it works.

CP2 10, 7. Night - overhead panel not very well; light - also copilot's side panel.

P3 10, 6. Present configuration, in my opinion, makes illumination of checklists and approach plates difficult. Small map lights are inadequate and the red forward floodlights too often are too much light under landing conditions for proper outside visual reference.

CP3 10, 5. The instrument lighting is good but the "map light" is gross. The red light feature is never bright enough to write by which requires white light from the map light and that destroys your night vision essential for see and avoid, comfort, depth perception, etc.

P4 7, 7. Good when operative. The useable life of some of these lights seems to be fairly short.

CP4 7, 4. At night the navigator has his lighting up for paperwork. The copilot has his map light on for paperwork. All of which destroys your night vision.

P5 9, 7. I rated night lower because it is often very difficult to read an approach plate at night. The map light doesn't do the job very well. The new approach plate holders help, but if there is any turbulence they jiggle so much that the approach plate is unreadable.

CP5 10, 8. Lighting on the throttle quadrant and stab trim and flap handle areas is not very good at all. All other panel lights are good.

P6 7. 7. Day - Panel washes out when sun is hitting the crew's face. Night - Good instrument deploys but poor for looking at material on the window edge and pilots' laps.

P7 7, 4. Front panel lighting is a 7, but general interior cockpit lighting for such things as approach plates, etc. is 4.

CP7 10, 7. For training purposes, when on a navigation leg where the copilot scores the nav's route, it is difficult to plot fixes in the right seat without turning up some lights which robs the pilot flying of some degree of his night vision. The map light is inadequate.

P8 2, 5. Day: Sun causes deep shadows and intense bright areas. My eyes cannot adjust rapidly enough when making scans and crosschecks. Night: Instrument panel, 7; overhead, 1 (radio/nav aid frequencies awful); sides, 3 (although seldom needed); pedestal, 0; floor, 0 (this is where virtually all paperwork winds up).

CP8 9, 2. Panel lighting is good, but visibility for reading anything is poor.

P9 10, 5. Needs improved map light arrangement for reading charts, approaches, etc.

PILOT/COPILOT QUESTIONNAIRE

MINIMAL UPDATE

AD-A088 035 BUNKER-RAMO CORP WESTLAKE VILLAGE CALIF ELECTRONIC --ETC F/G 1/2
TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION (TAACE). PHASE 0.--ETC(U)
MAY 80 G J BARBATO, R P MADERO, G A SEXTON F33615-78-C-3614
AFWAL-TR-80-3030-VOL-2 NL

UNCLASSIFIED

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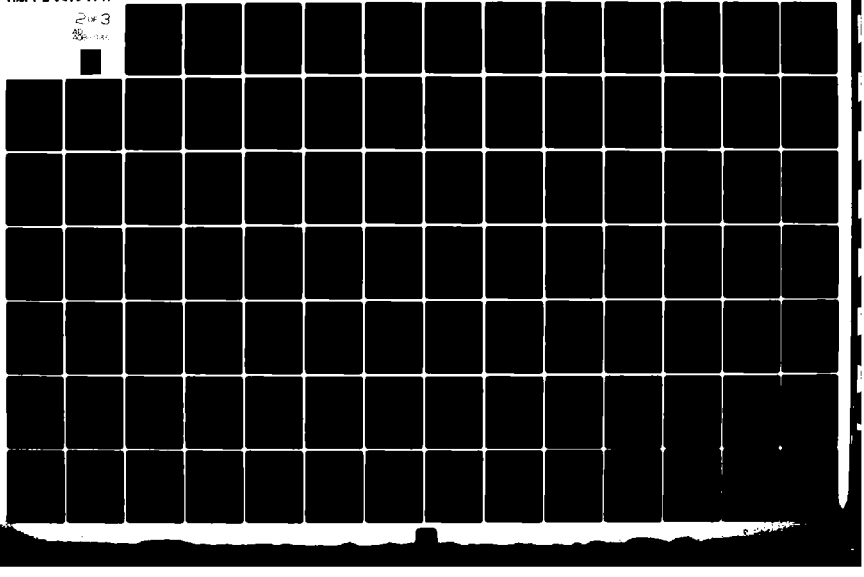
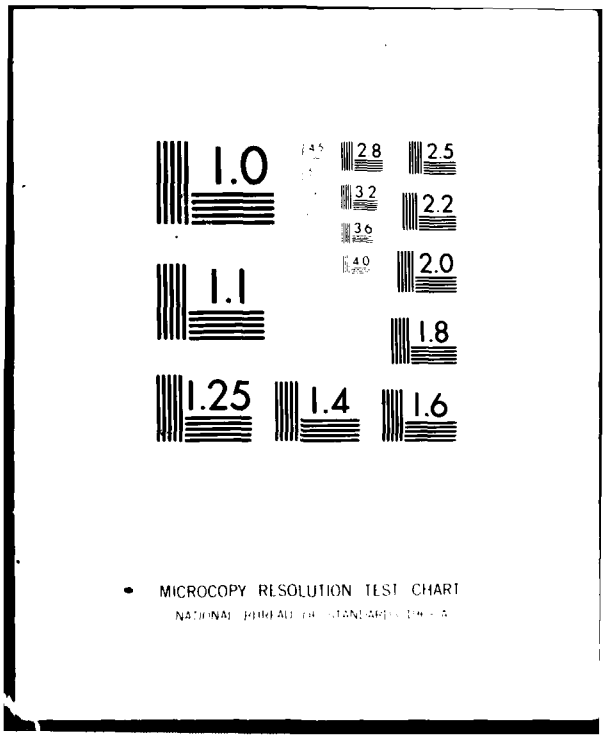
AD A088035

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2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

Compared to current tanker operations, rate how pilot/copilot workload would be affected if the navigator was replaced with dual INS, integrated with the flight director and HSI, the boom operator was given more/upgraded responsibilities, and the present KC-135 individual control and display units were generally left intact (much like the configuration you just flew):

Workload would be	0	Greatly increased
	1	
	2	Moderately increased
	3	
	4	Slightly increased
	5	Not changed
	6	Slightly decreased
	7	
	8	Moderately decreased
	9	
	10	Greatly decreased

Comments:

P1 2. The moderate increase would be maximum on the ground during preflight - programming INS and checking other systems. The other heavy workloads would be during AR in the weather or/and in cell formation. As far as a normal mission goes therewould be few problems staying ahead. One severe problem with "this" mod would be the location of the radar scope. This position is practically unusable for the pilot. Especially difficult during daylight operations.

CP1 3. Most time on flights, the actual flight path is monitored by the copilot. So the task of keeping up with aircraft position being the largest change for copilots, there is no real significant change in copilot duties.

P2 8. I feel that this configuration is feasible. The most important addition required for this configuration would be an upgraded radar for pilot use when flying cell in IMC condition plus during EWO conditions with curtains installed.

P3 1. The biggest deficiency I could see was that I would be staring at a lat/long display which meant very little to me in an overland environment,and even with selection of alternate INS modes I think position orientation would be very difficult - the normal nav aids (TACAN and VOR) would, as they are presently for the pilot, be the primary navigation reference during an operation such an anchor refueling.

In essence then, the copilot has become fuel manager, GCI (or ATC) communicator, forms filler-outer and navigator during air refueling in anchor while the pilot communicates with receivers, flies the aircraft and aids the copilot in all of his tasks to the maximum extent. I think this is unreasonable. During my 113 Young Tiger missions in SEA anchors my navigator was not sitting on his hands.

P4 0, greatly increased. This may change to a slight increase as the operator learns his new tasks. There is some disadvantage with having to update two separate systems from two positions. This could lead to a condition where the crew would be relying on one INS because they did not have time or could not remember to update both systems. As the new tasks are learned, the copilot would still be saturated depending on the difficulty or change in a mission.

CP4 1. It is hard to tell just how much of an increase due to the fact that we are use to using a navigator for other duties than just navigation. With just the PINS you have done away with copilot position not the nav's.

P5 5, not changed. Unless the crew had a new unexperienced copilot. Then the workload for the pilot would increase to about (2), but I don't think it would be a problem for the average A/C.

CP5 5, not changed. Carousel inertial navigation system makes it very easy to navigate to any where. It requires little work for crew members to keep it updated.

P7 2. Presented in proper sequence the workload didn't appear to increase greatly. However, the addition might be an overload under certain flight conditions. Copilot duties increase will distract him even more from following the pilot through on an inst departure or approach.

CP7 2. In general, with a few weeks of training on the system, the workload would increase slightly. However, during critical phases of flight, i.e. to climb, etc., the increase was great.

P8 0. The mission flown would have been impossible to perform. The change in ARCP was not navigated - it was guessed. At night, or in wx, the Rz would have been missed.

CP8 2. Workload was slightly increased up to the receiver's call and lead's problem, then it went all apart. The ARCP change would probably end up being a DR operation in most cases. Rendezvous problems with our beacon out (not an uncommon problem) further added to the load.

P9 2. Copilot would have greatest increase in workload.

CP9 2. I think the boom operator could do more with his INS system while the pilots are flying, i.e. departure, cruise, etc.

Please rate the quality of the information presented on the following displays: (Scale I)

Navigation displays (2 flight directors, 1 radar, 2 RMIs)
A/C engine and system instrumentation
Fuel control switching panel
Caution/warning system
A/C subsystems control indicators

Comments:

P1 The radar is not accessible to pilot. The radar pressurization and beacon mode panels are inaccessible to the copilot. The information from the flight directors and RMIs is very adequate. The doppler is not accessible to the copilot and would not be easily read by either the pilot or copilot.

CP1 The radar scope at the copilot's station is many times all but impossible to read.

P2 The nav displays would receive higher rating with improved radar for pilot use.

CP2 Caution system could at least use a master caution light to alert pilots to start looking around the cockpit.

P3 Not enough information displayed to the pilot without excessive switching during air refueling. The present KC-135 radar display is totally inadequate for normal use in daytime lighting conditions. The doppler information was displayed in an almost unusable location.

P4 The pilots may find themselves spending increased time looking at the center console distracting them from "see and avoid" and problems on the front panel. The overhead panel has always been difficult to use.

CP4 These systems have not changed from present configuration of 135.

P5 The quality (picture) of the copilot's radar is often times poor. This system would need to be improved for the 3-man crew concept.

CP5 Caution/warning lights are spread throughout the cockpit. It would be better to have the lights in one place.

P7 Radar quality poor.

CP7 The flight director is great and the compar. warning system is fair in that there is a big red light that flashes in front of the pilot's face telling him some relatively minor system is out of rig.

CP8 Flight directors are good, but without ground aids are limited to basic functions. Familiarity with the other systems probably make them appear better than they are. The fuel control switches should be colocated with the associated fuel gage as they are in this configuration.

P9 Everything at least "fair" but could be much better.

CP9 If the nav is going to be taken out, instruments should be upgraded to take the load off the pilots.

Please rate the capabilities provided by the following systems/displays (this rating is independent of how you rated the quality of the information): (Scale III)

Navigation displays (2 flight directors, 1 radar, 2 RMIs)
A/C engine and system instrumentation
Fuel control switching panel
Caution/warning system
A/C subsystems control indicators

Comments:

P1 All of this information is necessary. The information displayed is very basic and could be better presented and/or grouped on each of the respective systems.

CP1 No real change in any items from current 135.

P2 Most of these systems are useable and will get the job done plus hold down cost.

CP2 Tie-in of HSI to INS eliminates requirement of cross-cockpit or interphone communications to maintain course. All other systems were basically unchanged from current systems. Useful, but updating would make things nicer.

P3 In this configuration you would need everything displayed and more, probably.

P4 A master caution system is needed! Having a radar scope in a position where it is difficult for the pilot to see it is a definite drawback. Engine instruments have always been difficult to interpret exactly at a glance. Fuel panel is too large and is a waste of space. More time spent on the center console will detract from the front panel and see and avoid. The generator panel is difficult to see (and always has been) for just the pilot and copilot.

CP4 We are talking about relatives here. The systems are super compared to the 37's systems, but are antiquated compared to what they could have.

P5 Under the 3-man crew concept, navigation equipment would need improvement, i.e. better radar, install "PINS", 2 TACANs.

CP5 All of the above systems have been proved to be capable of doing the job.

P8 Scale III used only in sense of "enhanced beyond present real configuration" - "useful" not considered.

CP8 RMIs and associated flight directors are useless without ground aids. The radar is good but requires experience, plotters, dividers, and maps; and someplace to perform the operation other than a pilot's lap!

P9 Nav capabilities are the ones you should ask about. They are not as capable relative to other configurations.

CP9 I chose all 4 because all systems should be upgraded if the nav is taken out.

Using Scale II, rate the workload level required of the copilot to monitor fuel flow and fuel quantity information during refueling:

Comments:

P1 This system does not increase the workload to any great degree. During multiple fighter refuelings the copilot will be very busy. He is often aided by the pilot when things get too busy. A more reliable/accurate offload totalizer would help greatly.

CP1 With any crew duty, crew coordination is a must. If a copilot plans ahead, also there should be no real problem. In essence what I'm saying is with a "sharp" AC and CP that will keep ahead of the airplane,there should be no problem.

P2 The workload is similar to present mission workload except for added navigation responsibilities.

P3 I assisted over 50% of the time during this mission profile (anchor/ GCI) and we weren't even filling out the usual paperwork.

P4 His new duties will definitely distract to a certain extent. Weather radar and updating the navigation systems may lead to a forgotten switch. Pilots will have to crosscheck the fuel panels continuously.

CP4 I occasionally will be overloaded if I have a large offload and we are having problems with center or with the receiver.

P5 If the pilot assumed/conducted some of the copilot's duties, i.e. radar calls and navigation at the time of fuel transfer, workload for the copilot would not be increased significantly.

CP5 If fuel offloading is reviewed prior to takeoff,there is no significant workload. It is in fact quite easy. Many copilots are able to monitor many other things in the cockpit while offloading fuel.

CP7 During normal one receiver refueling, the workload is significant. If a problem in navigation or communication arises, there is a very good possibility for overload.

P8 In this mission, the exact offload was critical both from the receivers' viewpoint and the tanker's; therefore, monitoring the exact offload required great concentration. It would be a great help to give this function to the boomer in the pod.

CP8 With offloads that exceed the fore and aft body limits and require draining from other tanks greatly increases the monitor factor.

P9 Visual flow patterns combined with quantity indications better than other systems with no flow patterns presented.

CP9 I was a lot busier when I had to monitor the fuel. It should be with the boom.

Using Scale II, rate the workload level required of the copilot to relay fuel flow and fuel quantity information to the boom operator during refueling:

Comments:

P1 This is a very simple task and only complicated by an often unreliable offload totalizer.

CP1 The amount of work is no problem but excessive communication can be very dangerous during this critical phase of flight.

P2 This again is similar to present mission requirements. Pilot assistance is always available.

P3 We really didn't simulate this as well as we might have (or maybe we did) in that we missed several necessary comm calls between crew members.

P4 This task would be unnecessary if the forward body, center wing, and aft body gages were added along with the A/R pumps and offload totalizer. One drawback is the boom operator may be distracted from his primary job of safe refueling.

CP4 Again under normal conditions there is no problem relaying the information to the boom, but when things are going bad for one reason or another, it is just one more thing I have to do.

P5 I think the fuel switches and gages should be left where the pilots control them - leave as is. The boom operator has his hands full just flying the boom and being a safety observer.

CP5 It is really no much of an effort to do this, but it would be less talk on interphone if the boom could read this information out on his instrument panel.

CP7 No problem with single receiver, but with a cell formation with fighters it is often hard to get a word in.

P8 This is a very minor chore.

CP8 No problem here.

P9 Only need relay pump operation, fuel tank configuration information need not be relayed as during some other update scenarios.

CP9 I was a lot busier when I had to monitor the fuel. It should be with the boom.

Could the 3-man flight deck crew (upgraded boom operator) accomplish the preceeding KC-135 mission:

With all avionics operational?
Without the autopilot, but with all other avionics operational?
Without the dual INS, but with all other avionics operational?
Without the autopilot and dual INS, but with all other avionics operational?

Comments:

P1 It would be almost impossible to assume primary navigation without the INS system working. If the INS at the pilot's station was the only one working there would be no problem, however, if the "remote" INS was the only one working it would be very difficult to use during refueling. Assuming that we were only #2 in a cell - normally - the radar alone would keep us in position with #1 navigating.

CP1 Under normal circumstances the copilot and boom operation should be able to accomplish inflight duties while the pilot has control of the aircraft.

P2 The mission would become very difficult if navigation was based solely on utilizing the radar.

CP2 Navigation without dual INS could be accomplished if there were no short notice changes in flight plans. Even changes with up to 15-20 minutes notice would increase one or both pilots' workload greatly, possibly jeopardizing safety.

P3 Under today's profile (without nav aids, multiple FTR refuelings, emergency fuel situations, weather, etc.) I do not think the average crew could handle it and I doubt if the most experienced crew could short of the grace of God or a lot of luck.

CP3 Need some CRTs for map displays.

P4 Dual INS would be a necessity overwater unless the boom operator is fully qualified in sextant fixing. Without the autopilot, the pilot would not be able to alleviate some of the workload of the copilot and boom operator (weak yes). This could be disastrous because of minimum crosschecking.

CP4 Without the autopilot, but with all other avionics operational? Yes, only to the extent that there were no other problems that required the attention of the pilots. (i.e. mission change, diversion, bad weather, and system malfunctions)

P5 "PINS" absolutely necessary for navigation under this concept.

CP5 One INS set would be enough. One very good radar and doppler set would make it possible to perform this mission.

P6 On the mission it could be completed with the avionics but in the situation where the crew had to perform the rendezvous and maintain an orbit, it would be too much for a low experienced crew.

P6 If the boom was able to perform the rendezvous, it would relieve a lot of the pressure.

P7 This is conditionally yes. The mission could be performed depending on the crews level of experience and the time allowed. Without the autopilot, one pilot is most certainly spending 50 to 75% of his time flying. This will seriously limit his capabilities to absorb other crew member overload.

CP7 For EWO without the INS or a nav no way.

P8 Late navigational changes are too much to cope with when close to AR.

CP8 Could handle it up to the AR portion and possibly further without mission changes, but would be a real problem from then on.

P9 Depends on experience of pilots.

CP9 INS is essential if nav is gone.

Could a 2-man flight deck crew (without boom operator assistance) accomplish the preceeding KC-135 mission:

With all avionics operational?
Without the autopilot, but with all other avionics operational?
Without the dual INS, but with all other avionics operational?
Without the autopilot and dual INS, but with all other avionics operational?

Comments:

P1 Assuming the boom operator refuels only. It would be more difficult but an "experienced" crew could do the mission. A crew with a new or weak P/CP would have difficulty, especially during the multiple refuelings.

CP1 A 2-man crew could handle all the above situations if they were flying jet routes or direct between vortacs; however, on point to point navigation which is flown 90% of the time, the INS is almost essential.

P2 The possibilities of successfully completing the mission are much the same as the above situation.

CP2 Boom assistance in radio communications; station keeping; monitoring cell position; running checklists; and acting as safety observer is required. Without his/her assistance, workload becomes too great to fly the mission sans autopilot.

P3 The problem centers around air refueling - essentially a 2-man flight deck at that point - and I would say no to all but the simplest possible mission profiles. If this was not an air refueling aircraft with world wide capability,then the answers to both of the above statements would be yes in many instances.

P4 In the situation where all avionics work and no mission change occurs - yes. With heavier tasking on the pilot, the copilot would be a one man show and success would depend on his ability.

CP4 The workload would be extremely difficult even under normal conditions.

P5 Again "PINS" would be necessary. Upgraded boom operator would be very helpful, especially for copying messages and giving position reports/offload reports, and doing various paperwork.

CP5 Single INS would make it possible. Boom operator would be needed by the copilot to help to plot positions and to make radio calls.

P6 The boom's assistance is only minimal in this configuration.

CP7 For EWO without the INS or a nav no way.

CP8 Sorry. Too much too fast without adequate facilities.

P9 Boom operator does not assist as much in this update.

CP9 INS is essential if nav is gone.

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If no, what additional hardware would be necessary to make it possible:

P1 Yes. This is assuming that the boom operator could assist the crew. This "yes" is a qualified "yes" which assumes that they understand the systems and procedures to be used for this flight. In most large cells there would be plenty of help from other experienced individuals in the cell if a systems malfunction occurred. Normally lead or Head Dancer would not allow anyone to get into fuel problems.

CP1 Yes. With the proper training and a good simulator program, they should be able to fly this mission.

P2 Yes. I would say it is possible, however, it would be very difficult. As long as both pilots have basic systems training they should be able to handle a straight forward mission such as this one.

P3 No. The nav management system with horizontal situation display.

CP3 No. All the moderate equipment update at least.

P4 No. A front panel radar display. A reliable A/A TACAN capability. A means where both INS's could be crosschecked and updated expeditiously. A VHF panel that is centrally located. Also an unreliable autopilot could make this extremely difficult for an inexperienced crew.

CP4 No. Under the present 4-man crew,you would probably have problems with both the pilots' inexperience. As a bare minimum you would have to have an experienced pilot with all systems within his reach. The pilot would need to be responsible for programming the PINS, because even if the copilot did it the pilot would need to check it. The pilot's workload is such that it requires both pilots to crosscheck each other for safety of flight reasons. I doubt that a new copilot just out of Castle could perform the job as copilot/navigator.

P5 Yes. But only if they both received instruction and were very familiar with the use of the radar and PINS. In most cases it would not be necessary to team 2 inexperienced pilots together. A new copilot would generally fly with an experienced pilot.

P6 No. Some kind of system that would make orbits and rendezvous easier to accomplish.

P7 No. It's not hardware, it's time to accomplish all the tasks due to the low experience levels. Only greater experience and a high state of proficiency can accomplish the mission. Current levels of training would have to be increased.

P8 No. All of moderate update mod, plus paperwork storage/retrieval organizers.

CP8 No. Equipment easier to use to accomplish the mission changes. A route defined by nav aids that do not exist require maps, plotters, dividers and a place to work.

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If yes, what hardware (if any) could be eliminated and still keep it possible?

P1 Yes. Most decisions are made by Head Dancer or Lead when there is a need to reposition. A/C within the cell, maneuver around weather, or monitor the navigation.

CP1 Yes. I feel all the equipment would be needed.

P2 Yes. None. It would be extremely helpful to have a radar accessible to the pilot.

CP2 Yes. A qualified yes - both pilots would have to acquire proficiency with the INS, and I do mean proficient. The AOAs and RMIs could be eliminated.

P3 None.

P5 Yes. None, unless it would be one of the VORs.

CP5 Yes. They could eliminate the doppler if INS worked. All other equipment would be needed.

CP6 Yes. None.

CP7 Yes. The RMIs, ciphony control panel.

P9 Yes. Do not eliminate any hardware. Over water missions would be much more difficult than this one.

CP9 Yes. None.

What percentage of your total workload came from each of the following areas:

Navigation tasks	Aerial refueling tasks
Communications tasks	Paperwork tasks
Piloting tasks	Other tasks

Comments:

P1 The piloting and navigation tasks are often one and the same. The INS system can greatly enhance the pilot's navigational ability. More time would be required during preflight to program the INS but this would be greatly reduced by doing some good planning the day prior.

P2 Flying the aircraft is primary and navigation is second.

P3 I left a good deal of the navigation up to the copilot, by necessity. I failed to accomplish the necessary paperwork and doubt that I could have. I also missed several key communications and omitted others to my cell-mate -- communications forced itself very much into the fore-front while navigation was my key concern in this profile.

P4 Navigation is high at this point due to unfamiliarity with the system. Communication tasks are made unnecessarily high due to having a single HF head near the pilot and a VHF inaccessible to him.

CP4 I feel as a three year copilot I could handle the navigation and copilot duties given routine missions with minimal problems. However, when major navigation problems were to occur I would feel more comfortable at the nav station where I could lay out charts and plot courses, devote full time to navigation during major mission changes. i.e. track changes. However, as a new copilot I don't think I could handle it.

P5 If the aircraft experienced multiple emergencies, then the pilot would have to rely heavily on the boom operator to read and accomplish checklist. Therefore, he would need to be upgraded in this area. This would allow the copilot more time to monitor navigation.

CP5 This is about the normal workload that is presented in the current KC-135 mission.

P7 These values are averages and vary during different periods of the flight profile.

P8 Piloting tasks increase dramatically when flying cell wingman position.

CP8 Navigation requires too much time. If the mission could be flown as planned it would probably work ok (no equipment malfunctions).

P9 More piloting tasks with less sophisticated nav/comm systems.

CP9 Nav and comm still the workload.

Rate your required workload level to accomplish the following:

Navigation tasks	Overall level required to fly this configuration and mission
Communication tasks	
Piloting tasks	
Aerial refueling tasks	Overall level required by the other pilot to fly this configuration and mission
Paperwork tasks	

Comments:

P1 The copilot workload is primarily one of pacing. This is true on all flights and is also a direct reflection of experience.

P3 The simulated scenario was excellent and recreated the familiar "assholes and elbows" operation often inherent in anchor operations with multiple receivers and GCI control. I was totally maxed out and neither pilot was adequately watching the fuel panel during air refueling.

P4 The workload is high. Due to unfamiliarity a mistake in navigation or IFF procedures could occur. Also authentication and other communication and message procedures add to the workload.

P5 Overwater communication tasks could be greatly reduced by incorporating a better HF radio. This would provide a great deal more time to accomplish navigation tasks. If one pilot was required to fly the mission alone,he would have his hands full.

CP5 Very close to normal current day to day tanker missions.

P6 Piloting, A/R, and navigation workload level would significantly increase with the total loss of autopilot.

CP7 The individual tasks are not that taxing, but when they all need to be done at the same time the workload increases. Some of the work can be relieved with better mission planning.

CP8 Experience with the equipment would reduce the load to an estimated 6 level.

P9 Seemed more like normal mission, compared to additional tasks with other subsystems in moderate/major updates.

Overall, please rate the capabilities presented in this configuration for their usefulness/necessity in helping a 3-man crew accomplish the A/R mission. (Scale III)

Comments:

P1 10. All systems are necessary. The radar is necessary but unacceptable due to its location.

CP1 7. With an "experienced" boom operator a 3-man crew can easily accomplish the A/R mission.

P2 8. The dual INS provides accurate and timely navigation information which saves time and allows the crew to perform other required duties.

P3 10. Inadequate capabilities.

P4 7. Versus having a navigator this system is not as good. Under good conditions (missions with no variations) it is quite useable. However, a difficult mission may present an extreme workload.

CP4 7. Without the PINS the system would be totally unuseable. However, with the PINS it simply increases the copilot's workload.

P5 10. PINS, radar (updated), and HF (updated) would be required.

CP5 10. INS, doppler, and radar are required to perform in 3-man crew operations. VHF radios would also help.

CP7 7. A few weeks of training would be needed to gain the full benefits of the system.

P8 1. "1" is defined as "Wouldn't of didn't enhance mission performance whatsoever - not useful". What I really feel is that it would be outright fraud to tell an inexperienced (although qualified) crew that the mission is feasible in this configuration. It isn't.

CP8 3. Pilots end up with the map in their laps 90% of the time.

P9 7. Need a little bit more combined with increased training.

CP9 9. In this configuration, it is absolutely necessary for this equipment.

Rate your workload for the previous mission * for each flight segment: (Scale II)

Departure	Aerial Refueling
Climb	Descent
Cruise	Approach and Landing

Comments:

P1 The departure would be lessened if there was not any cell activity or a need to reroute the flight path to rendezvous.

CP1 Again crew coordination is the key to this program's success. The amount of workload could significantly increase with a lesser experienced crew member in any one of the three positions.

CP2 Emergency situations plus requirement for a weather ARDA increased copilot workload during approach and landing.

P3 The navigation displays are inadequate - flexibility wise - in providing the necessary information. The copilot was too saturated with navigation programming tasks to be a copilot. Once the boom went to the rear it was an extreme-to-overload situation constantly.

P4 Once the three crew members coordinate thoroughly to divide tasking, some of the workload will be alleviated.

CP4 The workload reduces with more time in AC.

P5 Better radar need to accomplish consistently satisfactory "ARAs".

CP5 Descent and approach and landing are demanding in any aircraft configuration.

P8 Cruise and AR were high because of flying formation as wingman. Although the lead air aborted, I am answering as if he continued the mission.

CP8 Changes make another whole ball game. No easy way to accurately move the ARCP, run the rendezvous, and check weather.

P9 Aerial refueling busiest time of mission. Approach and landing also.

CP9 More of a workload required in the minimal.

For the previous mission segment and cockpit configuration, please check which tasks were so difficult to accomplish as to pose a problem:

aircraft and engine systems monitors and control during normal operations
aircraft and engine systems monitors and control during emergency conditions
radar
fuel management
overall systems monitoring
see and avoid
terminal approaches
checklists
record keeping
Other (please identify)

CP1 The position of the doppler could present a problem. The pilot cannot effectively operate the set and the copilot cannot reach it.

P2 Radar is difficult to monitor by the pilot.

CP2 Emergency situations plus requirement for a weather ARDA increased copilot workload during approach and landing.

P3 No one area by itself was any big deal, it was the combination. I feel we fell well short in all of these areas. I could hold until we got our act together for a terminal approach, if necessary.

CP3 Navigation.

CP4 Radios at times. The radios were going so fast it was hard to tell who was talking to who and which radio.

P7 The addition of nav responsibilities to pilot and copilot causes us to be almost totally on inst. on departure, and the boom operator was also following and running checklists. Checklist ran by the boom operator causes pilot and copilot problems.

CP7 The VHF radio located on the pilot's side panel is a very bad location. It is very hard to get the boom to coordinate the checklists between the pilots.

P8 Navigating.

CP8 Navigation changes.

With the 3-man crew, in the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

CP1 No. Yes. The mission could have possibly been accomplished, but flight safety in some cases would have been compromised.

P4 No. Yes. Without an autopilot and an incapacitated crew member, accomplishing the mission would be hazardous.

CP4 Yes. Yes. Yes on the condition that it was not an experienced pilot and all systems were normal

P5 Yes. Yes or No. Two engines out on one side combined with an ARA approach with present radar, would require a lot of skill and some luck with poor wx.

P7 No. Yes. Possibly depending on skill level and place of occurrence.

Now, imagine the previous segment being flown by a 2-man flight deck crew. In the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

P1 No. Yes. A strong pilot could probably still do the mission, but a copilot would have a tough time doing the mission. Either pilot could recover the airplane safely.

CP1 No. Yes. To return home safely, it would have been necessary to have the maximum assistance from all controlling agencies.

P2 Yes. No. The only real problem would be the approach and landing. An airborne radar directed approach would not be safely accomplished by a single pilot.

CP2 Yes. Yes. Second situation would definitely require a proficient pilot (or copilot).

P3 No. Yes. But it would require a highly qualified copilot.

P4 No. Yes. Without an autopilot and an incapacitated crew member, accomplishing the mission would be hazardous.

CP4 No. Yes. Being safe, I would assume the pilot made it back alive.

P5 Yes. Yes and No. Maybe there would be a lot of factors involved here that could cause fatal mistakes to be made. The pilot would need time to plan the approach. With only 3000 pounds of fuel, he would have much time.

CP5 INS and radar would provide simple heading and distance for a suitable landing base.

P7 No. Yes. Possibly depending on skill level and place of occurrence.

P8 No. Yes. One pilot should be able to get any aircraft safely on the ground in any circumstance (malfunctions notwithstanding). Whether it will be at "home" or elsewhere is uncertain.

CP8 No. No. With a lot of luck and good DR there's a thin chance.

P9 No. Yes. This mission too complex, i.e. too many functional responsibilities existed, for one pilot to accomplish.

CP9 No. No. Three is the base minimum.

With the 3-man crew, what do you think would be the optimal division of labor for the pilot, copilot, and boom operator?

Comments:

P1 I question the need to fly an airborne radar approach.

CP1 Those items checked as predominately pilot and copilot duties could be switched on various flights so that each crew member could equally perform these tasks. Also on an ARDA,both the copilot and boom operator should be able to direct the approach.

P3 The navigation load is so greatly increased in this configuration that the pilot must expect to share many more responsibilities. Whether the pilot could now monitor the overall operation and provide the necessary clearing outside the aircraft at this point is questionable. The asterisk areas are those in which the boom operator could contribute significantly.

P4 Experimentation to provide equal task loading is necessary. The pilot will, as always, be continuously crosschecking other crew member responsibilities.

CP4 All tasks could be significantly changed given different experience levels of the individuals. At any case,the pilot would have to be able to accomplish both pilot and copilot tasks which would put him behind the power curve given an emergency.

P5 The pilot could reduce the comm workload for the copilot.

CP8 The VHF and HF should be installed on the overhead panel. The ciphony to the CP's side panel, and a radar scope at the boom operator's position.

P9 Paperwork functions should be boom operator responsibility.

Can you make relocation suggestions that might be better than what was demonstrated by this configuration?

P1 The radar controls should be colocated with the radar and the radar scope closer to the center of the console with a better daylight picture. Both INS control heads need to be accessible to the pilots. There is no substitute for an easily accessible, easy to operate, and easy to read scope. None of these are true in this case. The radar wx and station keeping modes are of utmost importance in order to accomplish our mission.

CP1 Both the beacon function of the radar and doppler should be moved to a different location for easier accessibility for the pilot and copilot.

P2 The radar should be accessible to the pilot.

CP2 Should put copilot INS control panel adjacent to programming unit. Fuel panel is old design, but switch and valve operation is positive and safe. (Not easy to accidentally actuate, as with a push-button panel)

P3 The doppler needs to be in a position where it can be referenced during an instrument departure and approach without head movement - preferably the center instrument panel, even if it displaced the true airspeed indicator. The HF should be moved to the center console. The radar is in a position unusable to the pilot,and the quality of the set is such that it isn't of much use to anyone during daylight operations.

CP3 Exchange locations of doppler down and IFF/SIF. It would be nice to reach beacon also,but prefer doppler next to INS.

P4 Two HF heads are necessary. Two INS's should be available (at least the information) for crosscheck by the pilots. The information on the front panel,as far as navigation and systems,is good but cross-checking is hindered because of new emphasis on the center console. The overhead panel has always been difficult to observe. A master caution system is a good idea.

CP4 The fact that both PINS heads must be programmed and updated each time is poor. One head should update both. Have VFF radio moved to center console. Master caution light for lights over pilots' heads. Radar/beacon controls out of reach for copilot.

P5 Communication equipment - HF control panel should be where boom operator has access.
Radar controls - Beacon function is a little bit unhandy.

CP5 The fuel panel is too big and it takes up a lot of space.

P6 The doppler and APN 69 beacon would be best located on the overhead panel opposite its suggested position and below the A/C lighting. The copilot could have access to the panel during rendezvous and weather navigation when the pilot is flying the A/C.

P7 Move the VHF comm radio to where both pilots can set it up for use. You can take the ciphony control panel and stick it any out of the way place. It's hardly ever used. The IGS is not in a very good place for the pilot to read it. A few inches aft would help.

CP7 The location of the VHF radio should be moved. Other than the VHF everything seemed to be in a useable place.

P8 INS (navigation displays, navigation equipment); IFF/SIF - all because of increasing width of pedestal.

CP8 The boom operator needs a radar scope. The VHF should be moved overhead. Possibly replace its location with the ciphony panel.

P9 Comm radios should all be reachable by both pilots. Copilot should have radar beacon control panel on his side. G-meter could be on nav panel. ADF would be nice, but not required.

PILOT/COPILOT QUESTIONNAIRE

MODERATE UPDATE

Rate how pilot/copilot workload would be affected if the KC-135 dedicated navigation controls and display units were replaced by a nav management system as conceptualized in the previous configuration:

0 Greatly increased
1
2 Moderately increased
3
4 Slightly increased
5 No change
6 Slightly decreased
7
8 Moderately decreased
9
10 Greatly decreased

Comments:

P1 3. Most of the workload change would be during preflight. This would involve programming the system and preflighting the equipment.

CP1 3. With no auto function on the fuel panel, the combined workload of a fighter A/R and a substantial input for the INS might be excessive so as to distract from other duties.

P2 2. With appropriate training the two pilots could handle this configuration, however, the workload is obviously limited or increased by individual proficiency. Good crew support from the boom will be the key to success with this configuration.

CP2 2. At certain times (refueling in weather with flight plan deviations) the workload would be quite heavy. Priorities of weather avoidance, navigation, and refueling might have to be arranged with some items momentarily ignored. Overall safety of flight probably wouldn't be compromised.

P3 10. I seriously doubt if today's profile could have been successfully flown without a nav management system,unless everything went perfectly without deviation or malfunction.

CP3 10. I would like to change my selection I made on the major update as it is the same in both. I would, therefore, like number 10 on both as I now realize more the capabilities of this system - essential.

P4 10, greatly decreased. With a little practice this system provides an extremely useful tool where the pilots can minimize the time it takes to update or change mission navigation.

CP4 8. As the system was set up, I would say this would be a minimum configuration to go to a 3-man crew.

P5 3. The workload would be increased somewhat. However, there is a lot of time during cruise that the pilots are doing very little or anything. So there would be plenty of time I believe for the pilots to navigate. No problem - during takeoff and descent and approach, the pilots are doing it anyways.

CP5 9. Nav management system leaves the copilot free to monitor all radios and aircraft performance instruments. The workload would be greatly decreased.

P7 2. At times this figure could go to maxi or saturation due to other crew responses and work.

CP7 4. During critical phases of flight there is a moderate increase, but overall there is a slight increase for the flight.

P8 8. Preflight workload/time is increased by the new system loading operation - the pilot would be finished with his exterior while the copilot was still struggling with checklist item 47. The pilot should probably be present for the loading operation for assistance and crosscheck for errors - a checklist realignment would do it. Inflight workload is greatly decreased when compared with manual methods. Experience with the equipment would cut the effort involved by at least 60%.

CP8 2. I believe the increase in workload would come in spurts. Takeoff/departure would be enormously complicated unless the crew was already familiar with the departure. This is true even with a navigator, but the workload is of course borne by three people. In particular the crew, however many there are, must be prepared to respond to unfamiliar routes, terrain, names, controllers who speak poor English and the inevitable apprehension that accompanies lack of experience. Information that can help them overcome these uncertainties is probably available, in the form of charts, FLIPs and mission folders; but the cockpit as presently configured (moderate) simply does not have the space needed to store and quickly retrieve this information as it is needed. If more information could be displayed, I believe the workload is negotiable.

P9 4. Workload would decrease over time with added experience. Increase due to number of functions/responsibilities, not difficulty of routine ones.

CP9 2. I think the workload has increased significantly, but once the pilots are trained it would increase to 4.

Please rate the quality of the information presented by the following displays: (Scale I)

Navigation displays (2 HSD CRTs, 2 bearing distance heading indicators)
A/C engine and system instrumentation
Fuel control switching panel
Caution/warning annunciator panel
Nav management system control/display units (2 keyboards, 2 CRTs)
Energy management (EPR command)
A/C subsystems controls indicators

Comments:

P1 The fuel controls during AR should be left up front primarily. This is due to the rapidly changing CG during AR which the boom operator has no idea what is happening with no fuel gauges. Especially when the pre-planned offload is changed.

CP1 INS scope is hard to see from copilot position when gear is down.

P2 The fuel control switching panel is in what I consider to be an awkward position. It seems likely that the control buttons could be inadvertently actuated by setting or dropping objects from the copilot's lap or just by accidentally setting objects on top of the panel. This happens a lot in the course of a flight.

CP2 Fuel panel should have switches in different order.

P3 The major mod design for the BDHI would be more helpful in monitoring position in relation to nav aids without using the HSI function - leaving the HSD available for radar and map displays. I would recommed that the original caution/warning annunciator panel indication be a flashing light which would go steady when the master caution was pressed. This would help prevent additional emergencies/failures from being missed in event of multiple system failures.

P4 The fuel control area is not easily visible and is not in an area that is seen visually with the pilots facing forward. Suggestion: interchange the positions of the fuel control panel and the AHRS.

CP4 I would like to see a fuel panel picture when setting up the fuel panel.

P5 Fuel control panel could be confusing the way it is now. An error here could cause big problems if not immediately caught.

CP5 All of the above systems give quality information and meaningful information. Tape engine instruments are great.

P6 Caution/warning annunciator panel could be much smaller and still functional.

CP7 BHHI is a good backup, but is not part of the normal crosscheck. The gage display is not readable to 100 pounds and the fuel switching panel is not logically set up. Some color coding would be good as far as major and minor EPs.

P8 Navigation displays are excellent, except I believe that I cannot fly an ARC approach in any mode except HSI and then have the ILS tuned for final interception and still have a bearing indicator for flying the ARC.

AC engine and systems instrumentation is excellent. I would prefer that the lineup of engine instruments be based on priority for "take-off" from left to right, i.e. EPR, EGT, F/F..... The fuel gage panel should have total fuel readout.

Fuel control panel. The panel is fine, but I'm afraid that inadvertent actuation (dropped checklist, etc.) could cause problems; i.e. any main tank drain valve to aft tank open. The panel location for boom operator operation is excellent, but does present a hazard.

Caution panel is excellent. Fire lights could possibly be wired into the same test switch.

Nav management system is great! Having to select for total fuel is inconvenient, however. The system should have a memory capability to retain the flight plan in the event the mission was changed and return to base was a "reversed course" operation. The concept of two different readouts on the CRTs is outstanding.

Energy management is of doubtful value unless entire mission is also flown in this concept; i.e. best altitude, best airspeed(AOA), optimum CG, etc.

Pin switches are good and the overhead location for the hydraulic panel is good. The battery switch panel should be moved away from the anti-ice panel to prevent inadvertent actuation of these switches.

Navigation displays are outstanding. The wx overlay on the map adds tremendous capability. The route displays add dimension to the entire flight plan. The displays greatly increase the pilot's orientation factors.

CP8 Navigation displays - Approach diagram needs improving; FAF, aerodrome, missed approach should all have distinctive symbology.
A/C engine and system instrumentation - It does not appear to me that the mod gives more accurate information, or saves space.
Nav management system control/display units - The quality of the information is great, but the format lacks easy recognition. Unfamiliarity may be part of the problem, but many of the abbreviations are just obscure.

Recommend that the "test" position on the annunciator panel also turn on all electrical panel warning lights, DH lite on radio altimeter, water lights and all FD109 annunciator lights. This

would allow all lights to be checked very rapidly during preflight. The "test" position would not be springloaded, since it could take 20-30 seconds to check all the locations.

P9 HSD mode selector switches would be better to right of pilot's HSD.

CP9 I rated the nav management system high because we used only one system and when the two systems are operating it would be great. The fuel control panel was not utilized by myself to a great degree, so I can't really judge it.

Please rate the capabilities provided by the following systems/displays (this rating is independent on how you rated the quality of the information): (Scale III)

Navigation displays (2 HSD CRTs, 2 bearing distance heading indicators)
A/C engine and system instrumentation
Fuel control switching panel
Caution/warning annunciator panel
Nav management system control/display units (2 keyboards, 2 CRTs)
Energy management (EPR command)
A/C subsystems controls indicators

Comments:

P1 The nav system should retain the degree/distance capability because geographic coordinates are not always available. This would also be especially useful when the AR track must be moved.

CP1 Fuel control switching panel should be located next to the tape gauges if possible.

P2 I think the fuel control switching system will be extremely useful after it is synchronized with the nav management system for automatic fuel sequencing.

CP2 Fuel panel may have to be moved to avoid accidental actuation by copilot. Automatic system would decrease workload and increase safety aspects.

P3 The possibility of overloading the pilot and copilot during rendezvous and air refueling with navigation, communication and fuel management is very real and worth another consideration of an automatic fuel management system.

CP3 Very nice but if dollars start cutting things these ought to go first.

P4 The caution and warning system of the major update is far superior.

CP4 The sensitivity of the keyboard for the navigation displays should be changed to reduce entry mistakes.

CP5 Fuel control switching panel could be confusing to inexperienced crew members, but that's to be expected.

CP7 Change the fuel panel to a logical set up and put it together with the gages.

P8 Keep the two bearing distance heading indicators for ARC approaches, DF, etc.

CP8 Nav management software program should be amended to allow direct position update from TACAN (or other nav aid) on PPSN. This would be especially useful in terminal operations where the cockpit is

very busy and the added accuracy of an update could be quite important.

P9 Fuel control switching panel would be better with some indication of fuel flow patterns.

Could the 3-man flight crew (upgraded boom operator) accomplish the preceding KC-135 mission:

With all avionics operational?
Without the autopilot but with all other avionics operational?
Without the nav mgt system but with all other avionics operational?
Without the autopilot and nav mgt system but with all other avionics operational?
Without the upgraded boom station?

Comments:

P1 Without the navigation information it would be impossible to navigate overwater. This is even more true when the track must be moved.

CP1 The autopilot is almost essential during critical phases of flight to accomplish all crew duties.

P2 I would have to say maybe for this one. We could get from point A to point B, but with mission changes i.e. emergencies, air refueling in weather etc. our success would be doubtful at best.

CP2 A shaky yes. Navigational standards would probably not be up to SACs current standards. We could get to the anchor; but once vectors, weather and emergency refuelings entered the picture the eventual recovery would become an emergency.

P3 With no autopilot axis at all the mission would be very difficult but, depending on the profile and crew capability, could probably be accomplished.

CP3 I have to see what it's like without the nav management system first, i.e. just plain INS - not sure yet how to use it.

P4 This is the minimum avionics and navigation configuration to accomplish present missions with a 3-man crew. The updated navigation updating, INS, and avionics are the key to transitioning to a 3-man crew.

CP4 The nav management system with the 2 CRTs is the key to the system, without that the nav could not really be replaced. The other things all reduce workload and increase safety.

P5 The pilots would have to learn to pass themselves closer, but I'm sure in most all cases there would be plenty of time to work the systems and still fly the airplane safely.

CP5 Mission could be accomplished with a minimum of TACAN, VOR, and inertial nav if overwater.

P6 With increased difficulty, the mission could be completed without the autopilot. It would increase the workload of the copilot, since the pilot would have additional piloting activity.

P7 With all avionics operational - conditional yes. The airborne radar approach would have to be changed and saturation could easily occur in the cockpit.

P8 The loss of the autopilot makes all other operations become a two man crew. Cruise flight could be accomplished but AR would be nearly impossible.

CP8 The operational autopilot seems to me the Achilles' heel of this concept. Without the autopilot, the crew has effectively lost one man, regardless of how many they started with. I also question the AHRS which replaces two gyros - the pilot's and copilot's FD gyros - with one.

P9 Depends on copilot proficiency with new systems.

CP9 I think the nav management system is essential, to take the load off the pilots.

Could a 2-man flight deck crew (without an "upgraded" boom operator) accomplish the preceding KC-135 mission:

With all avionics operational?
Without the autopilot but with all other avionics operational?
Without the nav mgt system but with all other avionics operational?
Without the autopilot and nav mgt system but with all other avionics operational?
Without the upgraded boom station?

Comments:

P1 This would increase the pilot load but not to the point that is would be impossible.

CP1 Most standard missions could be accomplished; but a fighter A/R with weather and subsequent moving of the A/R track would require efforts by both pilots thus necessitating an operational autopilot.

P2 The nav management system is of primary importance. Once it fails, we will be forced to rely on basic navigation and the upgraded boom would certainly earn his pay in those situations.

CP2 The workload would definitely be increased, but would not be unmanageable in the "yes" cases. Pilots would require basic navigation proficiency.

P3 If the boom operator was a part of the crew but not "upgraded", it is conceivable that the mission could be accomplished but it would be an "emergency situation" - too demanding to do on a regular basis.

CP3 Refueling impossible without a boomer.

P4 With one pilot experiencing further piloting tasks, the other may find himself unable to accomplish all the navigation and updating problems of a difficult or rapidly changing mission.

CP4 The workload and in the event of an emergency would be over taxing the pilot.

P5 I'm sure under this sytem a non-upgrade boom operator would not exist for too long because the pilots would teach him and work him to lighten the workload.

CP5 Mission could be accomplished, but the crew workload would double. The boom should be in a position to function as a meaningful flight crew member.

P8 Without the autopilot, priorities would have to be established. The pilot flys, the copilot navigates, the boom operator performs the refueling and anything else will have to be dropped.

CP8 The boom operator can help with some of the chores, but I believe they were relatively minor.

P9 Boom operator more necessary with degraded systems.

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If no, what additional hardware would be necessary to make it possible:

CP1 Yes. Significant ground training would be needed.

P2 No. I don't feel they could handle the navigation aspects of the mission. New inexperienced copilot would require hands-on experience before attempting this complex of a mission.

CP2 No. I believe the experience factor for the copilot is the primary stumbling block. The pilot will have to render more assistance to the copilot. This would work up to the anchor, but the workload for both pilots would be too much during wx avoidance, refueling, vectors, etc.

P3 Yes. Tying the autopilot into the nav management system/INS would greatly contribute to probability of success.

P4 Yes. Only if there were no changes of any kind (i.e. emergencies, mission changes) that could overload the capabilities of a young crew.

P5 Yes. But he would need more training so that he would be completely familiar with the system, what it can provide for him and what needs to be done to obtain the information from the system.

CP5 Yes. Training would have to be extensive, and the crew would need a thorough knowledge of all aircraft systems. The nav management system could be removed if the crew could get inertial navigation information.

P7 No. A better method and system for airborne radar approaches. A higher level of experience and proficiency would have to be maintained. A complete new fully equipped flight simulator at each station would be required to accomplish this.

CP8 No. Immediately available, organized information. This is what the HSD attempts to provide, but the amount of information is far beyond the display capability of the HSD, and often concerns itself with things that are wildly inappropriate to the HSD. For instance: taxiing out for a TTF cell, what is the tail number of the aircraft I must follow? After takeoff, ATC request confirmation of a route that appeared erroneously on the flight plan (and was thus erroneously, inserted into the CDU) and only reference to FLIP can help the question. During climbout an engine is lost and ATC wears you to hold at a local intersection you've never heard of. You are spare tanker for the first wave of a TTF, but not [illegible] automatically, spare for the second wave - while you have on board the return station paperwork for both waves. I honestly feel that this is one of the major problems in any modification, and it has received no attention by the hardware builders.

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If yes, what hardware (if any) could be eliminated and still keep it possible?

CP1 Yes. All hardware is required.

P3 Yes. The additional hardware on the boom operator's panel, although I think the passive monitor systems should be retained to reduce the communications task load. Because overlap and redundancy are so important without a navigator, I wouldn't want to fly this aircraft with any less equipment.

CP3 Yes. BDHIs; could go back to old fuel panel; A/C engine and system instrumentation; caution/warning annunciator panel; EPR command.

P4 Yes. None in this update.

CP4 Yes. The nav management system is the bottom line, loss of any one thing would not degrade the mission. However, the loss of more than that would increase the workload possibly beyond the pilots' abilitites.

P5 Yes. I think in most cases with thorough mission planning, you could remove the nav management system and still accomplish the mission.

CP6 Yes. A/C engines and system instrumentation
Caution/warning annunciator
Energy management

CP7 Ciphony, one of the TACANs, one BDHI.

P8 Yes. None. Any loss of the navigation equipment would be critical because of the lack of ground based nav aids (TACAN, VOR, etc.).

CP8 I see no real improvement in engine instrumentation, not even much saving in space.

P9 Yes. Minimum experienced pilot/copilot must rely on flight director systems to backup new methods. Keep hardware as is.

CP9 Yes. One of the nav management system.

Using Scale I, please rate the quality of the information contained on the following special function pages of the nav management system. In addition, please put your rating into what you feel to be the most appropriate "Information Amount" column.

CP2 Nav Aid Page - should give crews capability of inserting new nav aids into the computer.

Nav Aid Data Page - add whether HI/LO nav aid.

Fuel Status Page - need offload totalizer.

P3 Present Position Page - ETA information on the present position page (to the next waypoint) would be very handy and would probably result in this being the predominant display without having to check waypoint data -- although one NMS CDU could be kept in present position and one in waypoint.

CP3 Emergency Data Page and Map - I would like to see the capability of inserting three letter identifiers rather than looking and typing out N_ _ _ _ _ W _ _ _ _ _.

CP4 Hold/Rendezvous should have an alternate rendezvous feature built in. Possibility would be to have the ability to integrate mode 3 readout and ident feature.

CP8 Waypoint data page: suggest changes in terminology

"FLT PLAN" section readout

```
PPSN VIA FLT PLAN  ETA 1429:45
                   ETE   19:35
                  DISR  163.9
```

"PSN FROM BERRY" should be "PPSN DIRECT TO BERRY"

This would be much faster way of making up your mind if you wanted to make a quick diversion into Berry. I don't envision much need to know where I am in relation to Berry; where Berry is in relation to me is of more concern.

Fuel status page: replace "LBS X 100" with TOTAL (fuel)" (This is the most important number you need and it should be in the most conspicuous place.) Use a quantity format that the pilots use almost exclusively, i.e. 13.6 for 13,600 (as opposed to 136, which they have never used). Eliminate the plus signs - they don't clarify anything. Just skip a space.

In the configuration that you've just flown, please list the avionics you don't need (assuming the boom operator is "upgraded").

P1 Emergency data page could be eliminated with little problem.

CP1 The emergency data page could possible be eliminated.

P2 BDHSI

CP2 AOA, copilot clock, TACAN #2, could possible do without the BDHI.

P3 Other than the added items on the boom operator's station, I can't honestly think at this point that this aircraft with its mission could successfully flown with less. I would want to at least fly a real simulator mission prior to compromising this position,because I would have to be convinced that partial and or complete system failures would not totally abort the mission and possibly endanger the aircraft and crew without at least the moderate update configuration.

CP3 Same as 2 pages back provided "don't need" means same as could be "eliminated" as we could use and gladly use each one of these. We don't have anything in this mode we don't need!

P4 I recommend keeping all the avionics in this update.

CP4 None.

CP5 Emergency data page of flight management system.
Map function of flight management system.
Nav aid page.

P6 With map available on the HSD, it is not necessary.

CP6 Engine and system instrumentation; fuel control switching panel; energy management EPR.

P7 Needed it all plus an improvement in the fuel status page. This information will have to be displayed on a constant basis in accuracy to 100 pounds so both pilot and copilot and boom operator can see.

CP7 Ciphony, one TACAN, one BDHI.

CP8 New engine instruments.

P9 Fuel management panel, as presently designed, does not show fuel flow patterns and could lead to CG problems inflight.

Using Scale II, please rate the workload level required of the copilot to monitor fuel flow and fuel quantity information during refueling:

Comments:

P1 5. A good accurate digital readout is all that would be required to help our present system.

CP1 7. Without the auto function, it could possibly become excessive in the case of fighter refuelings and moving the A/R track due to weather.

P2 The workload level is directly affected by navigation workload. During ideal conditions the workload would be nominal. The pilot can aid the copilot during busy periods, updating the nav systems or operating A/R pumps.

CP2 4. Fuel page instant readout makes monitoring very simple. Navigation workload could make this duty somewhat more difficult in high pressure situations.

P3 8. I often found myself running the fuel panel during refueling while the copilot updated our nav status.

CP3 3. Not even a crucial point to consider.

P4 7. The switches are in the wrong place as mentioned earlier.

CP4 7. It is a reduction of the workload for the copilot but it may hinder safety in the boom compartment.

P5 2 to 1. I don't think this would be any more of a load than it is now. Once you are refueling down track and/or in anchor, little navigation update is required and the copilot would be able to handle the offload. Pilot would/could back up the copilot here.

CP5 5. No more of a workload than usual during anchor refueling. It is an aid to have the boom operator to switch on and off the A/R pumps, the offload is pre-programmed.

P7 6. The fuel panel switches are not easily understood or read. Plus the location of monitor and switches was separated such that it made it awkward to use.

CP7 7. There is a need to be able to read the fuel gages down to 100 pounds for offloading.

P8 8. This area requires considerable time to keep the CG and offload within limits.

CP8 1. Copilot doesn't need to monitor fuel flow at all - just to be generally aware of the total offload. The only reason either pilot needs to know fuel status is to decide whether to honor unexpected requests for unscheduled offloads. Knowing the total fuel quantity is all that is required.

P9 8. Need to have engineers design same presentation of fuel flow patterns.

CP9 3. I'm sure the workload would be occasional if it was working as published.

What percentage of your total workload came from each of the following areas:

Navigation tasks	Aerial refueling tasks
Communications tasks	Paperwork tasks
Piloting tasks	Other tasks

Comments:

CP1 Communication and paperwork tasks could be significantly different depending on the amount of workload the boom operator could handle.

P2 These figures will all change with the experience level of the individual.

P3 We were not accomplishing the engine monitoring form, form 76, etc. and did not have primary HF position reporting responsibility which contributed to our paperwork tasking being so low.

P4 The lessening of the workload in certain areas is enhanced by easier navigation updating as the crew learns to use these systems. This enables the copilot to help with communications and the pilot to help with navigation.

P5 With the information for station keeping put where the pilots are in control will cut down on confusion and interphone chatter. The pilots would always know their position and wouldn't be asking the nav for the information.

CP5 Having the boom operator read the checklist helps the pilots to pay more attention to switches and things outside of the aircraft.

P7 These are average workloads. During the landing phase with an airborne directed approach plus emergencies, pilot tasks climbed to 100% or saturation.

CP7 Total workload stress is dependent on the amount of time you have to accomplish a given task.

P8 Piloting is full-time, but communications have peaks and ebbs.

CP8 Other consists mostly of checklists.

P9 Nav and comm tasks increased due to nature of mission, i.e. catch up with cell, number of receivers, overseas procedures, etc.

CP9 Nav took most of my time probably because I'm still learning. Aerial refueling is good the way it is set up.

Rate your required workload level to accomplish the following (Scale II)

Navigation tasks	Other tasks
Communication tasks	Overall level required to fly this configuration and mission
Piloting tasks	Overall level required by the other pilot to fly this configuration and mission
Aerial refueling tasks	
Paperwork tasks	

Comments:

P1 The map with radar overlay is extremely helpful for understanding or orienting your flight path.

CP1 Workload levels could decrease with an increase in experience.

P3 This was our second simulated mission and besides the fact that the scenario called for more refueling and communication the crew coordination was somewhat improved. I missed some of the CDUs from the major update design but, for this mission, felt fairly comfortable.

CP3 Navigation tasks - still moderate but as I understand it better wkld goes ↓. I felt a big improvement since yesterday (on the major update). Communication tasks - I noticed the inconvenience of going to different places for various radios but we could live with it if we had to (i.e. the ICN would be nice but not necessary).

P4 As the crew learns to use these navigation systems, the workload reaches acceptable levels for any mission.

CP4 Given more time to become familiar with the system, it could become less than the workload now in the 135.

P5 I don't think that the workload would increase much at all from the present, if the pilots are familiar with how to operate the new systems.

CP5 As a crew member with 1500 hrs. in KC-135 aircraft, I don't feel that a crew that has had proper crew rest would be required to work very hard.

CP7 Since most of the easy parts of the flight were cut out, these ratings are based on the periods of intense work in a short period of time.

P8 Unfortunately, I believe I flew the mission as though it was autopilot off (I think I did this because of the loose wheel), and perhaps did not get as involved in the navigation portion as much as I should have.

CP8 The overall level would probably be inversely proportional to the experience level of the other pilot, but roughly equal for two fully qualified pilots.

P9 New configuration cockpits would seem to require an aptitude somewhat different from traditional seat-of-the-pants jet jocks. Misunderstandings and frustration with new systems could result.

Overall, please rate the capabilities presented in this configuration for their usefulness/necessity in helping a 3-man crew accomplish the A/R mission. (Scale III)

Comments:

P1 9. This arrangement is not saturated with multi-function CRTs which do not have constant readouts without changing function. Those readouts that are always visible are less confusing.

CP1 8. Substantial ground training could be required for minimally experienced crew members.

P4 10. Again the updated avionics and navigation systems are the key to getting along without the navigator.

CP4 9. This would be a minimum configuration if the nav was taken off the crew.

P5 8. The system would be very useful, however, not always would it be necessary. Many A/R missions, especially fighter A/R, could be accomplished without the navigator under the present configuration of the KC-135. To cover all A/R requirements the new systems would be necessary.

CP5 8. Nav management system is not a necessity. If inertial nav system providesnav information and other systems are easy to monitor,this is a very capable system.

CP7 9. The equipment and configuration was overall good, with the noticeable exception of the fuel panel.

P8 9. The mission would have questionable success without the installed equipment. It could perhaps have been flown with ground aids but would not have the flexibility.

CP8 9. With some improvement in software and/or procedures.

P9 7. Copilot crucial to overall mission effectiveness.

CP9 9. I do believe that this is the minimum to fly the mission.

Rate your workload for the previous mission segment for each flight segment.

Departure	Aerial Refueling
Climb	Descent
Cruise	Approach and Landing

Comments:

P1 The only portion that would be a little difficult in this case was the requirement to air update the system.

CP1 The only workload change to our current mission would be during cruise while programming the INS and the possible additional duties during A/R.

CP2 Didn't do descent or landing. Workload would have been light during these times.

P3 The communications load both within and outside the cockpit coupled with checklists and attempts to determine the best HSD modes was very high at times, but familiarity with the nav system management system would probably aid greatly.

CP3 The 5's and 4's are to be expected as much is happening in terms of piloting in short span of time.

P4 The new navigation system enabled the crew to change ARCPs and tracks with ease and little distraction.

CP4 The workload could be shifted if the boom were able to accept more responsibility.

P5 I don't think you would ever be overloaded because the navigator isn't here, unless you were not familiar with how to operate the systems.

CP5 Departure, descent and approach and landing are the busy times on any aircraft. These mission phases require a lot of a crew no matter what equipment there is available.

P7 Approach and Landing - possible overload at this point due to additional things pilots have to program,use and monitor.

P8 Communications were the critical factor. Much of this work would be handled by the copilot if a navigator was on board.

P9 Critical phases of flight require greater workload. Some tendency exists to back up basic flying/nav skills so much that you can miss important checklist items.

CP9 The late takeoff had a significant workload on myself.

For the previous mission segment and cockpit configuration, please check which tasks were so difficult to accomplish as to pose a problem:

aircraft and engine systems monitors and control during normal operations
aircraft and engine systems monitors and control during emergency conditions
radar
fuel management
overall systems monitoring
see and avoid
terminal approaches
checklists
record keeping
other (please identify)

CP1 There were none.

P2 Fuel management may become a real problem during compound or complex mission changes.

CP2 All of these become difficult during refueling. Especially during anchor refueling - this is true even in the present aircraft configuration.

P4 The caution and warning system in the major update is much better and enables the boom operator to help with emergency checklist procedures. Record keeping can be a problem with all 3 crew members involved in their primary duties.

P5 See and avoid could become a problem because the pilots would tend to keep their heads inside. Here again, however, familiarization with systems would reduce this.

P8 Communications were difficult because the copilot was involved with navigating, the pilot with flying. The systems we were familiar with were no problem, the nav system caused problems, but I do feel that experience with the system would overcome that.

CP8 The single biggest problem was not being able to lay my hands on the piece of paper I needed at the proper time.

With the 3-man crew, in the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

P2 No. Yes. The success of the mission would rest directly on the experience level of the remaining pilot.

P3 No. Yes. I should qualify my first answer with a maybe if the pilot or copilot was exceptionally qualified and with some degradation.

P4 Yes. Yes. The updated nav systems would enable one pilot to perform all tasks with some help in communications.

P7 Yes. Yes. If pilot was highly skilled and proficient.

CP8 No. Yes. Conditionally. In the context of today's flight, the X's stand; in other circumstances, they could change.

Now, imagine the previous segment being flown by a 2-man flight deck crew. In the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

P1 No. Yes. With no outside help, it would be difficult for one pilot to do the mission alone.

CP1 Yes. Yes. An operational autopilot and assistance from the controlling agency would be essential.

P2 No. Yes. The mission was just too complicated and the rapidly changing situation would prove to be too much for one pilot.

CP2 No. Yes. I question if this particular mission could have been safely performed without one pilot even with the navigator.

P4 No. Yes. One pilot would not be able to authenticate the necessary messages to accomplish an EWO mission.

CP4 No. No. I doubt if all aspects of the mission could be accomplished.

P5 Yes. Yes. Here again, the boom operator would be useful because the pilots would have involved him and trained him to be of assistance.

CP5 No. Yes. As long as the autopilot can keep the aircraft level, anyone pilot can manage the aircraft to a safe landing.

P6 Yes. Yes. The mission could be completed but with extreme difficulty if the aircraft autopilot failed. The additional piloting required by the pilot would quality of performance.

P7 Yes. Yes. If pilot was highly skilled and proficient.

P8 No. Yes. Again something has to give and it will probably be paperwork, clearances, etc.

CP8 No. Yes. Conditionally. In the context of today's flight, the X's stand; in other circumstances, they could change.

P9 No. Yes. Greater fuel constraints or nav requirements would have made it more difficult. As number 5 in 5-ship cell, station keeping not too time consuming.

CP9 Yes. Yes. It would be extremely difficult but it could be done.

With the 3-man crew, what do you think would be the optimal division of labor for the pilot, copilot, and boom operator?

Comments:

P1 A digital readout on CG would be very helpful if displayed on the fuel panel display.

P2 There are many segments which would be more effectively accomplished, and both pilots are capable to perform the task required.

P4 Further experience with a 3-man crew would lead to changes that would evenly distribute workloads.

P9 Same basic functions as what we're used to, but with boom operator picking up paperwork functions and back-up responsibilities.

Can you make relocation suggestions that might be better than what was demonstrated by this configuration?

P1 This arrangement was very good.

CP1 The copilot INS scope cannot be seen entirely with the gear handle down. The fuel tapes and the pump control switches should be located closer together.

P2 The fuel panel is in a position that may present a potential problem. Many times in flight the pilots place objects on the center panel. Many times objects drop onto the center panel. If this happens then there is a good possibility that the switches may be inadvertentally activated posing possible problems.

CP2 HSD and controls seemed to be hidden partially by control column. So many radios they tend to get in each others' way. Fuel control panel - switches should be rearranged.

P3 The UHF/DF on the copilot's BDHI is not visible to the pilot which is a definite drawback I feel. The Rz beacon is too far out of the way for the copilot to assist with - an inconvenience.

CP3 How about the possibility of moving one of the nav management systems to the nav position so the boom could use it? Need crew coordination between aircraft commander and boom to utilize his set while copilot uses his for navigating.

P4 Interchange the fuel control panel and the AHRS.

CP4 The front panel should be reserved for things that the pilots need to constantly monitor. Therefore, the fuel panel and AHRS should be switched with a pictorial display of the fuel panel.

P5 Looking overhead to select TACAN frequency then looking down lower left to select TACAN, HSI, etc. could cause problems with vertigo if flying in the wx.

CP5 IFF/SIF could be placed on the copilot's side panel if possible.

P6 ADF should be read on pilot's HSD instead of copilot's.

CP6 Put fuel display in view of pilots.

P7 Move the nav display CRT so it can be easily seen. It is presently hidden by pilot and copilot yoke.

CP7 Shorten the yoke so it is not in the way. The fuel control panel is not located near the gages.

CP8 1. The following should go on the overhead panel:
UHF 1 and UHF 2
VHF and HF
Both TACANs
Both VHF NAVs
IFF

To accomplish this, the air conditioning and electrical panel should be miniaturized, using pin switches. They are the two space hogs, and each could be reduced 75%. Then, all of the important comm radios and nav aids would be accessible to all three flight deck crew members.

2. The following should specifically NOT go on the overhead panel, because while they are important devices, their inflight use is extremely rare (i.e. the actuation of controls is infrequent):
   Radar pressurization (suggest copilot's side panel)
   APN69 (left wing of overhead, or boom operator station)

3. Fuel quantity should be a hard display, not a CRT call-up (although no harm in redundancy). Fuel pumps and valves should be colocated, not in a different area. The hard display of quantity should contain a constantly visible fuel remaining. Offload is unimportant, and should be monitored and controlled by boomer in pod. Pump and valve controls should reflect the flow diagram of the old panel, an excellent system and of great value with inexperienced personnel. Pin switches would do well, for both pumps and valves.

4. Location of start/start selector switches immediately aft and below of throttles is excellent, considering Alert response (copilot or boom operator may help start engines). However, additional protection against accidental actuation should be made, since accidental actuation could fire cartridge or cause starter to re-engage.

5. Nav management consoles are excellent, but software modification would help (covered elsewhere). HSD also looks good, but recommend pilot's HSD mode selector panel be in front of his right hand (he must fly, talk and slew with his left) and copilot's HSD mode selector panel should be in front of his left hand (similar reason). Also, copilot's clock should operate in front of his left hand.

6. Water injection controls could be virtually anywhere, and could use pin switches.

7. The center pedestal should not be widened. Space for reference material is critical to the point of safety being jeopardized. No more than one arinc should be overlaid. Recommend it consist of:

Throttle quadrant
S/SS switches
Autopilot
Radar
Radar Cursor Control
Rudder Trim

Reasoning: during cell operation, either pilot may fly the aircraft in this configuration. When keeping station by radar (night/wx) it is imperative that whomever is flying have instant reference to the radar and be able to manipulate the radar to adjust elevation, range and sector to give the information he needs without delay. Essentially, he needs to have his head buried in the scope (CRT) and his hand moving from the autopilot to the radar and back.

8. The warning annunciator panel is a great idea. It should definitely be included even if some of the smaller pressure panels (oil, hydraulic press/quantity) must be placed elsewhere. I recommend the test position of the annunciator not be spring loaded, so allow the crew to take their time to scan lights, and that ALL panel warning lights come on with the test switch (including electrical panel lights, FD annunciators, fire switches, marker beacons, MDA, GA, etc.).

9. Anti-ice switches, battery/ext. power switches/copilot instrument power switch, etc., all go very well on the overhead. By shrinking the air condition and electrical panels, there should be room for all of them.

10. Will the CRTs truly be readable in bright sunlight? Some thought should be given to permanent hoods canted toward the particular crew position. Removable hoods get lost (or may be inaccessible when the boom operator is busy). Moreover, we don't want additional space used for storing them when we don't have enough space now.

P9
1. IDENT switch for pilot's side (or on center console).
2. Move radar beacon control panel to copilot's side.
3. Mode selector switches for HSD to center of panel (right side of HSD for left seat, left side of HSD for right seat). Would preclude 3 movements if hand-flying.
4. Accelerometer on nav panel; we are required to write up G limits exceeded.

Using Scale III, please rate how much of a requirement exists for these boom station control/displays for 3-man operations:

Any comments?

P1 3. It would be hard for a boom operator to record figures for offload, etc. During large offloads the pilots would have to maintain a close watch on fuel distribution so they should control the pumps. A flow meter and a digital offload readout would be helpful, so he (boom operator) would know the progress taking place.

CP1 7. Fuel control by the boom operator might affect the boom operator's primary duty of air refueling.

P2 It may be nice to have equipment, however, I don't feel it is necessary. Only in rare situations would the boom be required to actually carry out the offload procedures.

CP2 8. For workload encountered during anchor refueling, boom fuel panel controls were very helpful. Especially helpful and highly recommended is automatic sequencing of fuel burning, draining, and offloading.

P3 The monitor displays of ff rate and total offload are good.

CP3 7. He only needs the totalizer and rate or flow indicator.

P4 7. He should also have the forward, center, and aft body gages if he is to manage the fuel as it is offloaded. This may pose problems since it would detract from visual contact with the receiver.

CP4 Workload decreased but possibly safety compromised.

P5 4. I think that the boom operator should keep his attention on the receiver and flying the boom. To have him turning on the pumps and reading gages could be a safety problem.

CP5 10. The boom operator should be able to plan his offload before air refueling. He is trained to be involved with aircraft CG. Pilots should be able to monitor fuel movement.

P6 Without the knowledge of individual tank totals, the A/R pump switches are useless. It would only cause more interphone chatter during the A/R phase. The fuel flow and totalizer would reduce talking on interphone.

CP7 3. It can be dangerous with two crew members working the fuel control from different parts of the plane.

P8 8. The pilots should have a total fuel gage for quick reference (the boom operator really doesn't need it),but the boom operator probably should have "slaved" FWD and AFT tank gages primarily to alert the pilots if fuel draining is required.

CP8 9. Navigation may very well consume almost 100% of the copilot's attention during AR; station keeping (cell) can overload the pilot. The boomer is perfectly capable of controlling fuel during AR, and the aircraft should be configured to give him that control, relieving pilot and copilot of that task completely. The only important provision is that a total fuel remaining readout should be constantly displayed at the pilot/copilot stations (not one that must be called up on a CDU).

P9 2. Idea to reduce interphone chatter good, but could be increased with unscheduled offloads, since boom operator has no access to fuel quantity readings.

CP9 9. I think it took a lot of the load of the pilots.

PILOT/COPILOT QUESTIONNAIRE

MAJOR UPDATE

Rate how pilot/copilot workload would be affected if the present KC-135 individual control and display units were replaced by an integrated communication/navigation radio frequency tuner:

0 Greatly increased
1
2 Moderately increased
3
4 Slightly increased
5 No change
6 Slightly decreased
7
8 Moderately decreased
9
10 Greatly decreased

Comments:

P1 7. The present systems display a constant always visible readout. This is not always true when one must select specific functions and carefully tune any new desired frequencies. Although the knobs are used in the older systems, they can be easily turned through detents easily without carefully looking at the digits.

CP1 3. Programming the INS will add to the amount of duties performed by the copilot, but the boom operator and automatic feature of the fuel panel should relieve the copilot of some of his duties.

P2 7. The system would save considerable time.

CP2 8. Having all the radios in one place saves having to look all around the cockpit to change channels. Also, the boom operator will be able to reach the controls.

P3 6. There is a definite advantage to keeping the comm/nav radios together so that you know where to reach to change a frequency. It is extremely difficult to imagine what working with this system would be like in terms of ease of operation and savings in time - particularly in comparison to our present UHF reset channel selection, for example. The positioning and ease of operation of the HF radios, on the other hand, was obviously superior.

P4 9. Good system. The convenience of operator use could be further increased with the use of preset frequencies. A button which could be used to click through a series of preset UHF, VHF, and HF frequencies would increase efficiency and keep the pilot's head out of the cockpit a few seconds more.

CP4 6. The slight decrease would be due to the central location of all radios and that all radios could be reached by both pilots. The call position for the HF is a good idea.

P5 3. More steps/time are required to select, tune, and channelize the radios under this system. The only advantage I see here is saving space.

CP5 2. Takes a lot of effort to make rapid frequency changes during critical phases of flight.

CP6 4. The centralization of the comm/nav is a good idea but would only slightly decrease workload.

P7 6. Improves copilot and pilot visibility to select frequency.

CP7 7. The workload would be decreased only in that the system is consolidated in one area.

P8 6. New location is better than old, but takes too many steps to insert frequency.

CP8 3. I have to accomplish more motions to change frequencies. I have to look at the switch to change the frequency, then look at the displayed frequency mode each change, set the command function. On conventional units, I look at the knob attached to the frequency wheel and make the change. The location is constantly covered with paperwork which often must be moved.

P9 It was good having one location for all frequencies, but selection design and frequency change procedures seemed cumbersome. 4.

CP9 2. With all the new radios, I think the boom is going to have to be more active in tuning and talking on the radios.

Please rate the quality of the information presented by the following displays:

Comm/nav frequency tuners
Navigation displays (2 HSD CRTs and 1 center CRT)
A/C engine and system instrumentation
Fuel mgt control/display with matrix back-up
Caution/warning alphanumeric readout
Nav mgt system display units
Energy management (EPR command)
A/C subsystems controls indicators

Comments:

P1 The fuel system automatic function is great,but if power is lost, there is no way of knowing what valves were open/closed,nor what fuel remains in what tanks. The instrument consolidation was excellent.

CP1 Digital readouts on all engine gauges would help to increase the quality of information on these instruments.

P2 EPR command is not necessary - funds should be directed more towards updating navigational equipment. The caution readout is another nice to have system that is not necessary.

CP2 Initial reaction to comm/nav tuners is they seem cluttered. Copilot's HSD hidden by control column - actual instrument may not be. Boom operator cannot reach keyboard on nav management system.

P3 The center CRT display is inadequately explained as far as its dual function in fuel monitoring is concerned. The hold/rz display as pictured in Fig. 6 & 7 displays too much past history and not enough receiver-oriented information,although I understand this is probably not a function of real capability.

P4 The master caution is an excellent idea. Fuel management could be made more efficient if the fuel tank within an aircraft display could be made available to the pilot's and copilot's HSD as another function. The electric panel has always been difficult to monitor.

CP4 Fuel management control should be displayed on center control with an added mockup of plane with fuel cells and pumps. EPR would be good even though we couldn't use it all the time.

P5 The quality of the information is very good. However, I believe there is an excess of redundancy. I think that the old checklists and flight plans are sufficient and need not be displayed.

CP5 To operate all the HSDs and CRTs, it takes a lot of programming or time.

P7 Navigation displays - HSDs need to be placed where yoke doesn't destroy pilot's visibility. Fuel management control/display with matrix back-up - Fuel management control is a poor replacement for the current system. The forward visual display is not accurate and will not be useful during offloads.

CP7 Shorten the yoke or move the HSD so that they are not blocked out. I think that the old fuel panel was good in that you could follow the logic of actual fuel flow. The new one should not be just a panel of push on panels.

P8 Annunciator is better than caution/warning readout, and CRT checklist response cannot be employed with the flexibility of printed checklists and -1.

CP8 Before I actuate a fuel panel switch, I must first visualize the tank-engine-drain relationship. Pin switches could be used in a tank-engine diagram location similar to the display on page 54(Major).

P9 Difficult to determine practicability of presentations. In theory, appear good and quality generally very good.

CP9 I would just like to comment on the fuel panel. I pressed auto on the fuel panel and let it go, I was just too busy with the other systems to be bothered with the fuel.

Please rate the capabilities provided by the following systems/displays (this rating is independent of how you rated the quality of the information)

Comm/nav frequency tuners
Navigation displays (2 HSD CRTs and 1 center CRT)
A/C engine and system instrumentation
Fuel mgt control/display with matrix back-up
Caution/warning alphanumeric readout
Nav mgt system display units
Energy management (EPR command)
A/C subsystems controls indicators

Comments:

P1 One thing which could be detrimental would be the numerous functions combined on one CRT, too many eggs in same basket, which could result in a great loss if only one component goes bad.

CP1 The current engine instrumentation is poor and the updated system is urgently needed.

P3 The SELCAL capability is super - I believe that if our command control system (I'm an old command post controller) could hook into this type of capability there would be definite operational advantages - particularly in day-to-day operation.

P4 Fuel management and caution/warning readouts were good. Fuel management capabilities would be increased if the boom operator had a forward,center, and aft body gage.

P5 Here again I feel the systems are overly redundant.

CP8 The center CRT seems like overkill. I could not see any advantage in the comm/nav setup, but can see many problems developing if it fails.

P9 Cockpit placement generally good. Nav displays would be enhanced with better location for mode selection.

CP9 Too cumbersome in the tuners/caution and warning very good, takes pressure off pilots to work other systems of aircraft while handling emergency.

Could the 3-man flight crew (upgraded boom operator) accomplish the preceding KC-135 mission:

With all avionics operational?
Without the autopilot but with all other avionics operational?
Without the integrated comm/nav frequency tuners but with all other avionics operational?
Without the nav mgt system but with all other avionics operational?
Without the control/display unit for fuel management, CG, checklists and take-off and landing data but with all other avionics operational?

Comments:

P1 (All nav aids and radios would be useless if this one piece goes bad) However, if the nav/radios were in their present form there would be no problem.

CP1 Without the upgraded boom station it could be much harder to perform.

P2 Navigation is again the deciding factor. The copilot will have to concentrate the majority of his efforts on navigating the aircraft.

P3 The second and third areas are marked not assuming this capability was lost, for example, after take-off. The CRT MPD for fuel management, CG, checklists, etc. would be essential for any mission other than the most basic. The monitor capability at the boom operator's station of fuel transfer rate and total offload is well worth while in reducing communications load.

CP3 I'd like to say no here also, as they are extremely helpful and essential but we could do it without it (fairly).

P4 The nav management and HSD systems are the key. Without them confusion and navigation/rendezvous errors would result. They are essential in a time limited/high task situation.

CP4 Although the mission could be accomplished with the absence of the integrated comm/nav, autopilot, and control display unit, they all help to reduce pilot workload. The absence of all three might make it impossible given an emergency situation.

P5 Boom operator would need to share comm lead and be familiar with systems operations.

CP5 All the equipment is capable of being backed up by another subsystem.

P7 Without the upgraded boom station? - The boom station upgraded did little to improve on the current configuration of the 135. The AR pump controls in his position in the pod along with the totalizer gage, etc. is of little use to him during receiver contact.

Without the control/display unit for fuel management, CG, checklists and take-off and landing data but with all other avionics operational?- The fuel management display is awkward and out of position (CRT) for the pilots to read with boom in rear of A/C. The offload (operation of A/R pumps by pilot or copilot) would be very difficult. It also limits the crew on the number of checklists that can be in progress at any given time.

CP7 I feel that we could offload our fuel with just one system gone and a normal ride.

CP8 As I understand the system, without the fuel management system (fuel quantity), fuel management would be a problem, but could be accomplished/I don't know how I would communicate without the tuners (but it might be a blessing!).

P9 Failure of one system may not preclude successful mission completion, but intermittent maintenance problems in addition to failure may be too much for three crew members to handle.

CP9 Nav management is <u>essential</u>! So is the boom! Needs lots of training all positions.

Could a 2-man flight deck crew (without boom operator assistance) accomplish the preceding KC-135 mission:

With all avionics operational?
Without the autopilot, but with all other avionics operational?
Without the integrated comm/nav frequency tuners, but with all other avionics operational?
Without the nav mgt system, but with all other avionics operational?
Without the control/display unit for fuel mgt, CG, checklists and take-off and landing data, but with all other avionics operational?
Without the upgraded boom station?

Comments:

CP1 There are too many duties to be performed by one crew member if the other pilot is involved with handflying the airplane.

P2 Experience and proficiency would be the deciding factor. Two inexperienced pilots would be unable to successfully complete this mission with any degradation to the navigation equipment.

P3 Unless you can figure a method of refueling without the boom operator.

P4 A 2-man, highly experienced crew could accomplish the mission as planned. If there were numerous changes, or with any navigation degradation, the mission would probably be unsuccessful. An inexperienced crew could find themselves in trouble because of the high tasking.

CP4 Yes, providing things didn't get so bad that the workload was too much for one pilot up front, i.e. five people trying to talk to him at one time.

P5 As long as you had an operable set of "PINS". If in cell formation with autopilot inoperable, a great deal more assistance would be required of the boom operator.

CP5 Boom operator is needed to assist pilots in some of their duties.

P6 Even though the crew could perform the mission as scored, the pilot and copilot could very easily get behind the A/C when malfunctions distract them.

P7 With all avionics operational?; Without the autopilot, but with all other avionics operational?; Without the integrated comm/nav frequency tuners, but with all other avionics operational? - Yes, but saturation would occur easily and the performance and safety of flight would be degraded.

CP8 Same comments as for a 3-man flight crew.

P9 Boom operator (well-trained) definitely important with complex system malfunctions.

CP9 Difficult but probable.

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If no, what additional hardware would be necessary to make it possible.

CP1 Yes. A large amount of ground training would be needed for any crew member with minimal experience.

P2 No. It would be extremely difficult with an inexperienced copilot.

CP2 No. Not a matter of hardware - experience is necessary. The late take-off, flight plan change and rendezvous would be the stumbling block. Everything else could have been handled by an inexperienced crew.

P4 Yes. This is a qualified yes. The potential and ability of the individuals would be the key. My opinion is that with maximum training, inexperienced crews could accomplish this mission quite easily.

CP4 Yes. Yes, providing other problems were kept to a minimum. All switches and navigation equipment all accessible to both pilots. The instrumention is easy to read and is displayed in pilots' logic. The instrumentation is relatively easy to operate.

CP5 No. No more additional equipment is necessary. But new crews would require additional training in all systems.

P6 Yes. Given that the crew had the practical experience with the system and had a chance to work together.

P7 No. Not hardware but experience will make the difference. The training required to maintain proficiency will have to be increased to a minimum of 1 to 1 1/2 flights per week.

CP8 Yes. No additional major equipment needed.

CP9 Yes. Castle would be a 6 month school!!

Could a minimum experience level pilot with a minimally experienced copilot fly this mission with this configuration? Yes or No

If yes, what hardware (if any) could be eliminated and still keep it possible?

P1 Yes. The nav aids and radio tuner could be eliminated. The checklist function could be eliminated. The CG and automatic fuel management could be eliminated. The fuel matrix could be eliminated.

CP1 Yes. The current KC-135 fuel panel could be used but would still need the auto function. The size of the panel might be reduced with micro toggle switches and digital quantity readouts.

P2 No. The BDHI, comm tuner, caution readout, energy management (EPR command) and A/C subsystems controls indicators. All of these systems could be eliminated without effectively degrading the probability of mission accomplishment.

P3 Yes. The integrated comm/nav/IFF tuning cockpit display.

CP3 Yes. ICN; A/C engine and system instrumentation; energy management; caution/warning alphanumeric readout.

P4 Yes. All this equipment is quite useful. The elimination of any particular system could lead to problems. Ease and speed of accomplishment are important if we are going to keep peoples' eyes out of the cockpit. The caution/warning panel could be eliminated if the master caution light were retained.

CP4 Yes. Possibly the elimination of the integrated comm/nav frequency tuners, and control/display unit for fuel management CG checklists and take-off data. While the mission could be accomplished without these,they do reduce pilot workload.

P5 Yes. I feel all that would be required for nav management would be a dual set of "PINS". The auto fuel management system would not be needed. Comm/nav frequency tuners could also be eliminated.

P6 Yes. Comm/nav frequency tuners. Even though the system consolidates the nav aids, I don't think that it is really that much more effective.

CP6 Yes. Integrated comm/nav frequency tuners, fuel management systems.

CP7 Yes. Ciphony control panel.

P8 Yes. Center CRT; fuel management display, if replaced by quantity panel.

CP8 Yes. Center CRT; comm/nav tuners; fuel management; TOLD; checklist equipment.

P9 Yes. Extensive training necessary and equipment would have to work well. Change (but not eliminate) comm and fuel subsystems.

CP9 Yes. None.

Using Scale I, please rate the quality of the information contained on the following special function pages of the nav management system. In addition, please put your rating into what you feel to be the most appropriate "Information Amount" column.

CP2 Need inbound heading on Hold/Rendezvous page.

P3 Fuel Status Page - Not used. I don't think you will need fuel information on all 3 displays (Nav Management, Master Radar/Fuel MPD and Fuel Management/CG/TOLD/Checklist MPD).

Hold/Rendezvous - The Hold at present position display seems inadequate in terms of length of leg information, INBD course.

Take-Off and Landing Data - Should incorporate EWO Take-off data.

In the configuration that you've just flown, please list the avionics you don't need (assuming the boom operator is "upgraded").

P1 We could do without the many fuel panel functions if we had a constant readout or presentation of fuel quantity in digits and switches for pumps and valves. A good accurate offload totalizer would be useful. The emergency data is not necessary the checklist is normally easy to use. A better presentation would be a constant readout on CG that would be a function of inputs into a computer. Tabulated data would be just as good as computer TOLD.

CP1 All avionics would still be needed so as to back up any crew member performing duties involving these systems.

P2 BDHI, comm/nav tuner, AOA, Emergency Data Page, caution/warning readout.

CP2 AOA; still not sure about BDHI, even though I "used" it once.
Fuel Status page on Nav Management System.
Emergency Data page on Nav Management System.

P3 The integrated comm/nav/IFF tuning display unit is great in that 1) it keeps all of the comm/nav radios together, 2) it saves space and, 3) it displays frequency information so that all can see it. But it's not what I would call necessary. With only the limited exposure that we necessarily have to this sophisticated update,I would hesitate to totally eliminate any other major avionics component,because the need for system overlap and redundancy is so great considering the mission and crew experience level. I would have two radar antennas if I could,just because of the fear of losing the system.

CP3 ICN; A/C engine and system instrumentation; emergency management; caution/warning alphanumeric readout.

P4 For an overwater, polar mission, these avionics systems are essential.

CP4 Take-off and landing data, CG computation. Although these are things that could be accomplished without the computer,it is time saving to have computer do them.

P5 Comm/nav frequency tuners. Center CRT (navigation display). Engine and system instrumentation would be nice but not necessary. Matrix control ok, but auto system not needed. Nav management system not needed if "PINS" are on board. Energy management (EPR) command not necessary.

CP5 Nav management system was not needed. The single integrated frequency control, fuel matrix, take-off and landing data display, caution/warning alphanumeric readout.

P6 Take-off and landing data, CG, ICN.

CP6 Comm/nav frequency tuners, EPR command.

CP7 Ciphony; only one nav management is needed; only one TACAN is needed.

P8 Center CRT; caution/warning panel; fuel management panel.

CP8 Fuel status; emergency data page; TOLD; CG.

P9 Comm/nav radio frequency tuner. Some functions of fuel management controls, i.e. I am doubtful about usefulness/ease of automatic management during ordinary mission profiles.

CP9 None.

Using Scale II, please rate the workload level required of the copilot to monitor fuel flow and fuel quantity information during refueling:

Comments:

P1 4. In this case his workload was greatly decreased due to the boom operator doing the work.

CP1 4. With the auto function and the "successful" management of the panel during A/R by the boom operator, the workload might be possibly decreased for the copilot.

P2 6. It will be of primary importance for the copilot to monitor the fuel panel during A/R. The auto system will help deviate some of this workload. Changes in offload must, however, be updated in computer to maintain a proper and safe CG.

CP2 3. Auto fuel system is very nice.

P3 5. As long as the automatic function works normally this should be no major problem. The anchor air refueling with GCI and multiple receivers should be considered in the requirements for this systems capabilities.

P4 5. It would be a better idea to allow the copilot to operate the pumps and monitor the fuel panel. It should be the boom operator's responsibility to keep a good visual reference of the receiver at all times.

CP4 2. The thing that was nice was when things got fast up front,the boom could run the offload while I just monitored it.

CP5 3. Auto fuel system takes little or no effort at all.

P7 7. Increased workload due to position of quantity information and switch location.

CP7 The fuel panel in its present location and size is unacceptable. Change the panel to a more logical presentation. Color coding valves, tanks and pumps would help somewhat on the present system.

P8 There is no requirement.

CP8 5. Fuel flow information is not generally important - total quantity needs to be monitored.

P9 5. Visual presentation good, but automatic fuel management programs would probably have to be changed continuously, due to changing offload requirements.

CP9 5. I'll say 5 because I didn't work it that much because I depended on it while I was doing other tasks.

What percentage of your total workload came from each of the following areas:

Navigation tasks	Aerial refueling tasks
Communications tasks	Paperwork tasks
Piloting tasks	Other tasks

Comments:

P1 The navigation system gives a lot of good information. It also requires a lot of care when updating or changing in flight. The tradeoff is about equal.

CP1 The communication tasks might be possibly decreased if the boom operator can effectively coordinate the A/R through the GCI for the receivers while in the pod.

P3 Position awareness is always a major portion of "piloting" to me - this, of course, relates directly to navigation.

P4 Although navigation is greatly improved from a pilot's standpoint, communications loads are increased with 3 crew members and the addition of an extra radio.

CP4 Although the overall workload distribution does not change that much from the min system, the workload itself is greatly reduced.

P5 Navigation required more time basically,because use of the equipment was still somewhat new to me.

P6 This assumes that the autopilot is on and functional. If the autopilot is out a greater % would be required under piloting.

CP8 Comm tuner location and operating problems caused more effort than really should be required. Unfamiliarity with the nav system caused more time requirement than an experienced operator would experience.

P9 Copilot functions appear to be less related to flying/backing up flying the aircraft.

CP9 I was working the navigation equipment. Probably once I know what I was doing, it would drop to 40-50%.

Rate your required workload level to accomplish the following:

Navigation tasks
Communication tasks
Piloting tasks
Aerial refueling tasks
Paperwork tasks
Other tasks

Overall level required to fly this configuration and mission
Overall level required by the other pilot to fly this configuration and mission

Comments:

CP1 The workload level would probably decrease with an increased experienced level.

P3 Refined checklists, training and crew coordination might well change these figures.

P4 The communications seemed to be the major workload factor during this mission.

CP4 The copilot's workload is increased. However, not to the point that it degrades the mission, and in many instances the mission is upgraded with this system.

P5 Workload on copilot would be higher because he would be responsible for updating nav equipment. Pilot normally would just monitor.

CP5 Due to the amount of equipment to monitor,the workload is greatly increased.

CP7 The comm was hard because of the lack of coordination between the crew. The air refueling was tough because on the set-up of the fuel panel, as far as who was turning on pumps when.

CP8 Unfamiliarity resulted in a higher workload than normal.

P9 Copilot requires more alterations in habit patterns and learning new techniques.

CP9 Again navigation was my concern, individuals need training.

Overall, please rate the capabilities presented in this configuration for their usefulness/necessity in helping a 3-man crew accomplish the A/R mission.

Comments:

P1 7. One function that would be useful would be a "groundspeed required" to arrive at a specific time.

CP1 9. The mission can be very effectively performed with this modification.

P2 10. The most important items are the navigation equipment.

P3 9. Without having flown the other two update configurations, I can easily say that although I could accept a somewhat lesser capability in some of the displays or systems, I wouldn't want to toss out my navigator without some capability in every area and a lot of overlap/redundancy in the navigation and flight instruments.

P4 10. The accelerated avionics and navigation equipment in this configuration enables a 3-man crew to accomplish the navigation and communications problems of this mission. The speed with which a navigation problem can be solved is the key. This must be done rapidly to enable the copilot to do his primary task, backing up the pilot during critical phases.

CP4 8. All radios and nav equipment were accessible to both pilots and boom. Although the mission could be flown with just one nav management system control head, two would be just that much better.

P5 3. Too much capability. Not needed, might even be confusing to new pilot.

CP6 10. Nav system essential.

CP7 9. It's an excellent system. Well advanced from the present, with the possible exception of the fuel presentation.

CP8 9. It would be difficult without the nav equipment.

P9 7. Seemsto be a few systems too complex for their own good.

CP9 9. Not knowing the other mockup situation, I would need all equipment to accomplish this mission.

Rate your workload for the previous mission segment for each flight segment:

Departure	Aerial Refueling
Climb	Descent
Cruise	Approach and Landing

Comments:

P1 Having a combined radar and INS map was especially useful.

CP1 The workload for A/R would probably be decreased after coordination of duties were worked out among the 3 crew members.

P2 The rapid changes to the mission caused the crew to fall far behind the aircraft.

P3 I rate these areas so highly mostly because of the problems induced which increased the workload somewhat.

CP3 Navigation plus emergencies kept workload moderate from EAR to touch-down.

P4 Communications with multiple receiver cells and the GCI presented the highest workload.

CP4 The overall workload would approximate the workload now, if not reduce a little.

P5 HSDs are very good. They would make departures, join-ups, and approaches much easier and error free.

CP5 Nav management system, comm/nav frequency tuners and fuel management control/display, caution/warning alphanumeric readout requires too much attention inside the A/C during approach.

CP7 It's an excellent system.

CP8 Changes during departure and climb and receiver problems increased the workload.

P9 Presentations tend to duplicate basic instruments, possibly at expense of good crosschecking during critical phases of flight.

For the previous mission segment and cockpit configuration, please check which tasks were so difficult to accomplish as to pose a problem:

aircraft and engine systems monitors and control during normal operations
aircraft and engine systems monitors and control during emergency conditions
radar
fuel management
overall systems monitoring
see and avoid
terminal approaches
checklists
record keeping
Other (please identify)

P1 No particular problems once crew is familiar with the equipment.

CP1 Under this mod, there should be no problem with an adequate amount of training and the equipment operating properly.

P2 Navigation changes inflight.

P3 The multiple control inputs for radar and navigation (such as radar cursor, press bleed, beacon, etc.) spread about over different areas and the variable displays available were occasionally confusing.

P4 Until all the systems are worked with awhile, the crew will be spending a lot of time with their heads in the cockpit.

CP4 I do not foreseeany segment providing more of a problem than already exists.

P5 Use of the equipment would not be a problem once a crew was familiar with its operation. Until that time "See and Avoid" could be a problem.

CP5 Too much equipment to monitor during descent and landing phase of flight.

P6 See and avoid was a problem simply because of EWO configuration and secondly, the lack of system expertise.

P7 In the sense of increased workload inside the cockpit. Improperly positioned so that crew members can back each other up, can't readily see.

CP7 Fuel management during refueling is questionable. The boom should not be the one to read the checklists for pilots in the A/R.

P8 Aircraft control after loss of autopilot aileron axis.

CP8 None would pose a problem but would keep you busy at times.

CP9 See and avoid - I was worried about the nav system too much.

With the 3-man crew, in the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

P2 Yes. Yes. Based solely on a highly experienced pilot.

CP2 Yes. Yes. If the incapacitation occurred after cell join-up.

CP3 No. Yes. No, if it was the boom operator,as very few pilots can refuel. Yes, if it was a pilot.

P5 Yes. Yes. Only under extreme conditions (i.e. wx, multiple emergencies, fuel low, etc.) would these be the possibility of an accident.

P7 Yes. Yes. Yes, with highly qualified people. Not with the current crew level of proficiency and experience. Possibly the aircraft could be flown home safely.

P8 No. Yes. Due to A/P aileron axis.

Now, imagine the previous segment being flown by a 2-man flight deck crew. In the case of incapacitation of one pilot, could the mission still have been performed? Yes or No

Could the aircraft have been flown home safely? Yes or No

Comments:

P1 No. Yes. With no other crew member to help, it would be very difficult for one pilot to do everything up front.

CP1 Yes. Yes. To update the INS and perform other duties, it is almost imperative the autopilot be operational.

P2 Yes. Yes. With a straight forward mission without any changes, it would be possible.

P3 No. No. I can't conceive of a way this mission could be flown with less than 3 crew members.

CP3 No. Yes. No, if it was the boom operator as very few pilots can refuel. Yes, if it was a pilot.

P4 No. Yes. One person could not have accomplished all the tasks in the flight deck area.

P5 Yes. Yes. The probability for error would rise sharply.

CP5 Yes. Yes. If all avionics are functioning without malfunction.

P6 Yes. Yes. With a 2-man flight deck, the job would be extremely hard, but with the available systems it could be accomplished.

CP6 Yes. Yes. Navigation system would make this possible.

P8 No. Yes. Due to A/P aileron axis.

CP8 Yes. Yes. As #2 in a cell, many of the navigation tasks would have been provided by the lead aircraft.

P9 No. Yes. Experienced pilot with well functioning systems could perform this mission.

CP9 Yes. Yes. Very difficult.

With the 3-man crew, what do you think would be the optimal division of labor for the pilot, copilot, and boom operator?

Comments:

P1 The "hands on" flying should be shared by both pilots.

CP1 Pilot and copilot duties should be switched so that each crew member can effectively perform all cockpit duties.

P3 I feel that in all areas marked with an asterisk the boom operator could contribute significantly to better (smoother) crew coordination and flight safety.

P4 The pilot controlling the airplane could continuously update both weather and position with this HSD system. The pilot not flying would primarily work with navigation updating. Communications loads would be evenly distributed for maximum efficiency. Other tasks would be divided to evenly distribute the workload.

CP4 With this system I think there is a better distribution of the workload, plus it allows the pilot to monitor more of what the copilot is doing.

P5 The pilot would need to assume some of the traditionally copilot duties, such as ate, comm.

P6 Under aircraft control, the phases could best be accomplished by the pilot since he has more experience in case of problems. But either pilot could fly them under normal circumstances.

P7 The copilot will now have more of a role in decision making than ever before.

CP8 Boom operator could handle all the fuel work during cruise or descent portions, but the copilot would have to work it during A/R.

P9 Crew coordination even more important. Additional VHF radio and TACAN impose greater conflict with other procedures,and hot mike feature cuts out other radio calls at times.

Can you make relocation suggestions that might be better than what was demonstrated by this configuration?

CP1 The gear handle in the down position blocks the copilot's INS scope so that he has difficulty programming it. A solution to this problem might be to replace the current handle with one the size of a T-37 handle. The checklist readout might be placed somewhere else so that it might be seen easier by the pilot and copilot.

P2 The boom operator should have some access to the nav management system for keeping up with aircraft position in relation to flight logging. Hydraulic pressure switches should move to left side of overhead panel for quick and easy access by the pilot. Many situations require immediate depressurization of a particular hydraulic system, and they are a little tough to get to where they are presently located.

CP2 Nav management system should be useable by boom operator.

P3 Grouping the radar controls more would help. The systems controls were somewhat inconvenient to reach (and see) - in particular the overhead panel groupings. I would be tempted to try putting the radar bleed on. The right side of the overhead panel below the beacon and move the anti-ice, instr. pwr and hydraulic control panels to the left side. The ciphony is used so little (even during Young Tiger in SEA during my 113 missions) it could be moved to a less convenient place,perhaps if that would make room for say, the hydraulic and instr pwr panels.

P4 The battery switch should be centrally located on the front panel.

CP4 The mini switches over the copilot's head should be larger and protected from being turned off by mistake. I don't think it is necessary for the BDI to be able to be set to different frequencies. There needs to be some kind of alternate rendezvous put into the system. During rendezvous I would like to see distance between aircraft, offset, and turn range on digital readout. During ILS you need to have a continuous DME readout. I would like a fuel panel display on the center screen displayed similar to how it is displayed now.

P7 The navigation displays - Put nav display up higher where it isn't hidden by yoke. Put switches, etc. behind yoke.
The fuel control panel - Improve display and put it with control switches.

CP7 Cut down the size of the yoke to be able to see the HSD. The fuel panel needs to be changed.

CP8 Nav, comm, and IFF should be individual controls and mounted overhead.
Hydraulic switches should be located with the gages.
Panel location is good, but should have gages with it.

P9 I would leave master caution light where it is, and switch nav display mode selector buttons with caution panel.

CP9 No need to work with the system!

Using Scale III, please rate how much of a requirement exists for these boom station control/displays for 3-man operations:

Any comments?

CP1 8. It should be used if it does not affect the boom operator's primary mission of safely offloading fuel.

P2 7. Due to inexperience the copilot had to depend on the boom to handle the A/R pumps. It would only be in rare cases that a boom operator would be required to actually accomplish the offloading of fuel. This situation would promote safety hazards due to excessive crosschecks required by the boom operator.

CP2 6. The automatic fuel system greatly reduces workload, so it wouldn't be that much more work for the copilot to run the fuel panel.

P3 7. The boom operator will probably seldom have the time/opportunity to run the fuel pumps from the aft end because it involves diverting his attention from observing the receiver and controlling the boom. The monitor functions - offload rate and totalizer are a different matter as I've said above.

CP3 5. Especially the AR pumps aren't required. Workload during after the Rz is almost nil even when copilot is required to do all the offloading.

P4 An increased instrument workload for the boom operator will lead to increased air refueling incidents. Unless a heads-up display was provided, I would not recommend this modification. If a heads-up display was included,then these pumps and gages along with gages for the forward, center, and aft body tanks should be provided. The HSD system would greatly enhance rendezvous capability if the bearing and distance of the receiver were digitally presented on the HSD in HOLD/RZ and radar mode. A continuous update of the receiver's turn range could also be presented digitally based on his TAS and drift.

CP4 Although the workload was reduced for the copilot, I think that it would be unsafe for the boom to be watching the fuel offload instead of the receiver.

P5 An offload totalizer in the boom compartment might be useful, but pilots should be responsible for offload and C of G.

CP5 6. Boom operator should have an offload gage at his station.

P7 Get rid of, no value.

CP7 5. It would take some crew coordination to be able to effectively use this system. Without it, it would be very dangerous to have two separate crew members operating the fuel panel.

CP8 The pilots need to total fuel gage - the boom operator an offload gage. I noted a great decrease in monitoring requirements.

P9 Need to keep watch and control of fuel transfer up front.

CP9 Took a lot off of the pilots.

PILOT/COPILOT QUESTIONNAIRE

POST MOCKUP

With no navigator, if the boom operator flight deck duties and responsibilities were expanded, how valuable would his assistance be with the following tasks?

Comments:

CP1 The usefulness of the boom operator could be different for various missions (i.e. pax delivery, fighter exercise refueling).

P2 I really think it is more feasible to upgrade navigators to be air refueling experts. The boom operator would require extensive training before he could become qualified to fill the gap left by removing the navigator.

P3 We really didn't duplicate the paperwork load well in these evaluations and may be missing the impact of all of the silly forms we keep our heads in our laps filling out. The boom operator is going to have to be a giant step above today's average to handle these responsibilities.

P4 Much of the paperwork, systems monitoring, and communications would have to be handled by the boom operator to fly safe successful missions.

CP4 It is hard to say just how much the boom operator could handle since there is a wide range of experience among booms.

P5 The boom operator would be upgraded in his responsibilities, if not at Castle AFB then by his Aircraft Commander. Upgrade at Castle would be preferred.

P9 Boom operator role much more important and would have to understand more of aircraft systems and procedures. Major role as back-up essential.

Using Scale III, rate the requirement to have a "Boom Engaged" light or indicator on the copilot's side in addition to the one on the pilot's side:

Comments:

P1 4. This light could be placed on the fuel panel or near the panel matrix and both pilots could use one.

CP1 9. While controlling the fuel panel or monitoring the number of contacts, it is essential the copilot be able to see this light.

P2 1. The light is visible from both positions. It could be raised slightly so as not to be blocked by the center console.

CP2 2. I can see pilot's boom engaged light. In addition, there is radio conservation to confirm a hook-up.

P3 5. Improving the present location on the pilot's panel so that it isn't obscured by the fuel panel would help.

P4 2. Really not necessary.

CP4 9. As copilot I must lean over to see the light and on days that the sun is shining on it, it is impossible to tell if it is on. It may only be necessary to have it centrally located.

P5 2. Boom engage light on pilot's side is easily seen from the copilot's seat.

CP5 10. It would be very useful.

CP7 9. Since the copilot is usually doing the refueling it should be on his side.

P8 10. Absolutely required for B52 and C5.

CP8 1. One is enough.

P9 5. Not required as long as one on pilot's side easily visible.

CP9 1. One is enough.

What communication equipment is required/desired for accomplishment of the KC-135 mission?

Comments:

P1 The VHF would be useful mostly overseas, especially in Europe. The 2 HFs would be useful for overwater flights due to the high rate of failure on the current HF. SELCAL would be very nice to have to rid the need to monitor HF.

CP1 The VHF is urgently needed now and a new HF radio is also needed.

P3 The SELCAL would be great if tied into the world wide command control communications system because it could eliminate HF monitoring during critical flight phases (particularly air refueling).

P4 A VHF is extremely useful as is inclusion of two HF heads, one which is accessible to the boom operator.

CP4 VHF radio would be very helpful working with ctr. Particularly when one HF is down and the other is used for AR. More reliable HF radio or dual HFs.

P5 HF radio definitely needs to be upgraded. VHF radio would be a great help, especially overseas.

CP5 VHF is needed now!!!

CP8 I need two VHFs or VORs with COMM REC capabilities. An additional HF as a backup would prevent many overwater shorts.

P9 VHF may be required in overseas areas. HF required but must be improved if possible.

What navigation equipment is required/desired for accomplishment of the KC-135 mission?

P1 The INS should be capable of accepting a radial/DME off from VORTACs or waypoints.

CP1 No other required or desired.

P2 One necessary item required to aid a crew in successfully accomplishing SAC's varied mission is a qualified navigator. It is more feasible to train navigators to air refuel.

CP2 Fully qualified navigator? It might be a lot easier to give the nav an INS, the copilot a nav management system (or vice versa) and teach the navigator to refuel and accomplish boom preflight duties.

P3 What we need on the "1 Required" items is reliability! The present doppler system is very poor in this respect, for example. The "Two Required" items I feel are so important as to demand redundancy because their loss would cause a mission abort on the majority of missions.

P4 The Omega system should be incorporated at least in the KC-10, which will fly numerous overseas deployments.

CP4 Depending on the reliability of the system,the dual requirements could be deleted.

CP5 INS

CP8 Altitude alerting system; VNAV. I sure would like to have a count up/down clock.

P9 More than one sextant required without INS.

Using Scale III, please rate the requirement for selectable digital readout capability on engine instruments and subsystems pressures and quantities in addition to scale readouts:

Comments:

P1 8. Without the digital readouts,there would be interpolation problems on some items such as EPR.

CP1 9. The current engine gauges are very difficult to read during take-off role, especially EPR.

P2 2. These are nice to have but unnecessary and costly.

P3 5. Greatly simplifies instrument comparisons and adjustments.

P4 9. Extremely useful in everyday operations. Also enables safer instrument monitoring during critical phases of flight.

CP4 9. With the tape type of indicators they would be mandatory, the old system would be adequate.

P5 3. The only one that digital readout might be useful for would be EPR.

CP5 9. It would help the pilot to make rapid and accurate instrument readings.

P6 6. If the scale on EPR 9 tape is large enough to be readable to the 100th digit then a readout is not necessary.

P7 10. Accuracy is very important.

P8 7. Especially useful for takeoff power.

CP8 9. Oil pressure readouts are especially needed.

P9 7. Scales good; digital readouts very good.

CP9 9. Makes it easier on the pilots.

Which do you feel is the minimum avionics update level required to perform the KC-135 mission?

Dedicated controls/displays (present KC-135) plus INS
Integrate all nav functions into one control/display
Integrate all comm functions into one control/display
Integrate both comm and nav functions into respective control/display units
Other (please specify)

P1 I do not feel that the 2-man flight deck is realistic. The biggest need is a good radar and a mapping display for the INS system.

CP1 To effectively accomplish the mission with a 2 or 3-man crew,the minimum avionics are the same.

P2 The pilots and upgraded boom operator (or upgraded navigator) should each have a control/display unit.

P3 Clarification - two integrated nav displays are mandatory; the comm portion is adequate presently,although it could be improved.

CP4 The integrated nav system is a must without the other items there is increased possibility of the workload becoming too great under abnormal situations.

P5 In addition to "PINS", an updated HF radio would be needed. A better radar, VHF radio, and a HSD for both pilots would be very helpful.

P8 The mission would still depend on the autopilot and AHRS gyro.

Using Scale III, please rate the requirement for an accelerometer ("G" meter) information display to accomplish the KC-135 mission:

Comments:

P1 1. This instrument has no great value.

CP1 3. It is never used during normal KC-135 operations.

P2 1. Have never used it.

P3 3. Only time I've seen it used is when severe turbulence is encountered.

P4 5. Seldom necessary. The information is useful if moderate to severe turbulence is encountered since the aircraft can be over-stressed quite easily.

CP4 2. The only time it would be of any good would be if due to any emergency a large number of Gs were pulled, you would have a reading.

P5 1. I never use it. The only thing that I can think of that it would be used for would be to record in 781 "Gs" applied to A/C during hard landing or when encountering severe turbulence. None of which have I encountered.

CP5 1. "G" meter is absolutely not needed.

P7 10. Required for flight.

CP7 2. Not normally used.

CP8 1. None.

P9 2. Only necessary to record hard landings or limit load factors exceeded.

CP9 3. Boom needs to write up exceeding limits.

Using Scale III, please rate the requirement for all annunciations to be on a CRT with a computerized priority listing:

P4 7. Allows much easier and safer systems monitoring.

CP4 7. Reduced workload due to checklist feature and auto priority system.

Using Scale III, please rate the requirement for having emergency checklists integrated with the annunciator panel and automatically displayed on a CRT:

P4 7. It would enable the crew to monitor aircraft performance and would keep the pilots' heads out of the cockpit.

CP4 8. For that one time you don't want one pilot looking in a checklist.

CP7 3. There is the possibility to be running more than one checklist at a time.

Please list those systems which should have controls on the yoke (either on horns or on center shelf):

P1 The present systems are adequate on the yoke. I would recommend that the horn and rudder controls stay on the center shelf.

CP1 *The current setup is adequate.*

P2 No really good suggestions.

CP2 RGA; trim; HSD controls.

P3 All present controls plus a slew switch for the projected heading display shown in Figure 12 of the major update section (p 32) would be helpful. An autopilot/INS interface engage/disengage button on the center shelf (so as not to be confused with the autopilot disengage on the horn presently).

P4 Comm selector switch, the HSD function switches.

CP4 Pickle feature for FD-109, autopilot disengaged, slew for RMI, function control for CRT's, radio com select switch.

CP5 INS keyboard could be on the yoke.

P6 Existing systems.

P7 Autopilot; RGA; trim; mike; interphone; interphone control selector.

CP7 Warning horn cutout, RGA, com/interphone.

P8 Altitude reminder.

CP8 Clock with count up/down controls. Pitch set for FD-109 command bars.

P9 HSD mode selectors (on center shelf); present switches.

Which systems should be computer programmable (please list, i.e. CG, TOLD, fuel management, checklists, nav aid tuning)?

P1 I would prefer to have CG readouts and a TOLD card presentable. The fuel digital readouts below the graph display would be suitable.

CP1 Nav aid tuning; TOLD; fuel management; checklist; nav aid tuning; hold/rz function.

P2 TOLD, fuel management, flight planning, CG.

CP2 TOLD; fuel management; CG; flight plan. A lot of paperwork could be eliminated if the nav and fuel system could automatically record their data for later use.

P3 TOLD definitely; fuel management definitely; CG preferably (mostly as a crosscheck on the automatic fuel management system). Checklist would be a beneficial convenience. The fuel management program should include the capability to figure time-on-station/offload capability with a "BINGO" fuel inserted. I also very much like the idea of a flow diagram since we need a picture of our fuel configuraiton somewhere and this could be essential in a fuel leak/emergency tank emptying situation.

CP3 CG; TOLD; fuel management; nav aids.

P4 TOLD; fuel management; emergency checklists; CG; all navigation; all rendezvous functions including continuous updating of receiver's distance, bearing, and update of turn range; interrogation of receivers mode 3 as an alternate rendezvous feature in case of beacon failure.

CP4 Navigation; holding/rendezvous; mapping; radar/radar fixing; fuel management; checklists; CG computation and take-off landing data; nav aid tuning; caution/warning system; autopilot.

P5 CG; take-off data/landing data.

CP5 CG and TOLD only.

P6 CG; take-off and landing data; navigation; present position-direct; change in flight plan; flight plan; HSD; holding; RZ.

CP6 TOLD; nav aid tune.

P7 TOLD; checklists - if properly displayed and more than one check can be run; nav aid tuning; nav systems.

CP7 TOLD; nav aids; CG; fuel management; flight planning.

P8 CG; TOLD; nav aid tuning (i.e. Why not set frequencies using nav management keyboard?); fuel management (use manual during AR).

CP8 TOLD card and CG.

P9 CG; TOLD; fuel management - based on altitudes, airspeeds, gross weight, and not entire mission profile.

CP9 CG; TOLD; fuel; navigation.

Which systems should be completely automated (Please list, i.e. fuel management, checklists, approach/landing computations)?

P1 I believe that first priority would be the approach and landing readouts. A completely automated fuel management function would be nice with an audible signal when switching is taking place on valves, etc. This would be a good method to remind pilots to check fuel distribution occasionally.

CP1 TOLD; fuel management; approach/landing computations.

P2 Fuel management; approach/landing computations.

CP2 Fuel management; CG computations; approach/landing data computations; take-off data computations.

P3 Fuel management definitely; TOLD (with EWO take-off data capability). If an integrated comm/nav system were incorporated I think the frequencies should be programmable into the order in which they are anticipated to be used (i.e. ground control, tower, dep cont, ctr...) because that is essentially what our present UHF radios offer with their present function.

CP3 Fuel management.

P4 Approach and landing data; emergency checklists.

CP4 Fuel management/with manual override; approach/landing computation; commanded EPR; CG computation; nav tie in with autopilot.

P5 CG; take-off data/landing data.

CP5 Approach/landing computations and GWT and ZPR readouts.

P6 CG; take-off and landing data.

CP6 Take-off and landing; nav.

P7 Approach/landing computations.

CP7 TOLD data.

P8 Fuel; TOLD computation; recording inflight progress - fuel log, nav log; nav aid tuning (punch in on nav management keyboard - rest is automatic).

CP8 Approach and landing computations.

P9 TOLD; HSD functions.

CP9 Approach/landing; fuel.

Using Scale III, please rate the requirement for an HSD vs. and HSI:

Comments:

P1 9. This puts most of the much needed information in front of the pilot where it is easily used.

CP1 8. The HSD is a very effective aid in reducing the amount of cockpit scanning required.

P2 10. The HSD is an extremely useful instrument it used to its capacity.

P3 10. I don't think the anchor orbit/contingency profile could be successfully flown without it.

CP3 9. HSI useless in anchor areas, need a map display.

P4 10. The added functions of map display and radar display plus any combination of the two is absolutely necessary.

CP4 10. To replace the nav it is absolutely necessary to perform the mission. With just a INS you do not replace the nav, you replace the copilot.

P5 9. Very useful when conducting rendezvous/cell join-up in the wx.

CP5 5. The HSI does a very good job.

P6 10. HSD is necessary for radar weather watch and beacon monitor.

CP7 9. HSD next best thing since liquid butter.

CP8 9. Could not accomplish effectively without it.

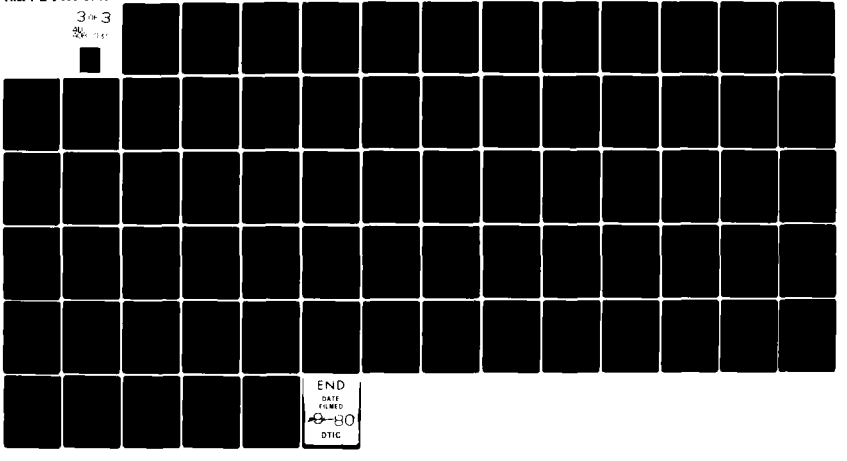
P9 8. Very good, especially with adequate training.

CP9 9. It would make the pilots' workload a lot easier.

AD-A088 035 BUNKER-RAMO CORP WESTLAKE VILLAGE CALIF ELECTRONIC --ETC F/G 1/2
TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION (TAACE). PHASE 0.--ETC(U)
MAY 80 G J BARBATO, R P MADERO, G A SEXTON F33615-78-C-3614
AFWAL-TR-80-3030-VOL-2 NL

UNCLASSIFIED

3 OF 3



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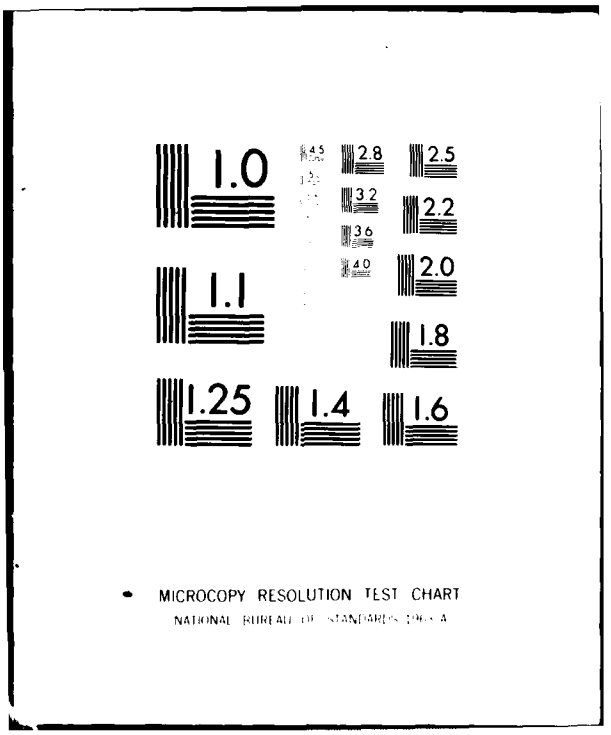
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Using Scale III, please rate the requirement for a color HSD as opposed to black and white HSD:

Any comments?

P1 9. The color would help eliminate the need to interpolate what is being shown. Pilots do not have much experience with using radar. The color would be a great aid.

CP1 7. Colored wx on the HSD would it make it much easier for the crew members to analyze any impending wx.

P2 5. Black and white is sufficient. Color may cause problems at night with the red/white lighting in the cockpit.

P3 9. It would seem to greatly enhance weather avoidance capability which could mean a great deal during overwater task force deployments or contingency-anchor refueling conditions.

CP3 7. I have to use my imagination on this.

P4 8. It would be very beneficial in weather avoidance and provide a way to differentiate between different symbols and clutter.

CP4 9. I would like to see color HSD on the center HSD for wx. It would be very helpful navigating around weather.

P5 8. A good black and white would probably be good enough.

P8 0. Pure luxury.

P9 5. With two independent HSDs, overlays not as critical as with one HSD or two non-independent HSDs.

How realistic was the mockup experience?

Comments:

P1 The syllabus was very good and the work put in to this program is admirable. I feel that the program will result in an effective plan to build a simulator with good results. One problem was my inability to believe that certain systems are reliable. The only way that I would feel comfortable with certain automated systems would be more hands-on or data from those using this system presently. The reliability of the navigation system would have to be unquestionable for me to start from Hickman to Guam for example. Confidence in the equipment - in summary - is what I'm talking about. I feel that I will have this confidence after using an INS system with AF maintenance.

CP1 The pacing of the mission was probably the strongest point of the mockup. It is quite apparent someone did their homework concerning the KC-135 operations.

P2 I commend those responsible for the scenarios. The missions were very close to actual missions. There was little problem imagining that we were flying an actual mission.

CP2 The close approximation was a close approximation of the workload encountered on similar missions.

P3 The scenarios and scripts are excellent. The major drawback is that you can't actually evaluate how successfully you are accomplishing the mission unless you have the ability to get off course or drain too much fuel aft or miss a rendezvous. I do think the typical fuel, comm (TACCOM), flight progress, engine condition monitoring, AFTO Form 76, etc. should be provided during simulation to more realistically represent that aspect of the mission.

CP3 A superb job with what you had. I was impressed.

P4 This was an extremely valuable exercise. The problems encountered were very realistic and the mockup configuration could be evaluated as to capabilities quite easily. I could see what was necessary and unnecessary from this experiment because of its realism and research.

CP4 Some parts of the mockup were more realistic than others. The most realistic was the comm. I thought for the extent of the mockup the realism was excellent. The stresses and problems associated with the mission were enhanced by the fact that people played their parts well and the radios were very realistic.

P5 I think the mockups were good, but a real simulator will tell you/crews a lot more. Because it will force the crews to do more than just go through the motions.

CP5 It is great simulation through sound and actions. It would be great if INS could show changing positions.

CP7 The personnel running the mockup did an excellent job in trying to give a real situation, however, it was still extremely difficult to project at times.

P8 Had little to do with flight at all, but was effective in focusing attention on the equipment and procedures.

CP8 Because of the loose control column, I flew the whole first mission as though it was autopilot off, so I suppose I was more than somewhat involved.

P9 I think the experiment was somewhat unrealistic in that we were by no means proficient with the new systems. As a result, we were preoccupied with systems which were supposed to reduce our workload. Should have had INS head on minimal update.

How did the unrealistic aspects of the mockup influence your answers on the questionnaire? Were you most likely to underestimate or overestimate the difficulty of the following tasks?

Communication tasks	A/R tasks
Navigation tasks	Rz tasks
Piloting tasks	Other tasks

Comments:

CP1 Any new procedures will probably cause the evaluator to overestimate its difficulty. The estimate would be decreased with an increased experience level.

P2 Lack of knowledge in certain areas resulted in underestimation.

CP2 I can't really make an accurate estimation due to the fact that the equipment didn't work; I wasn't too good at using it; and there was no real feedback on my actions.

P3 I concentrated on the different phases but it was easiest to simulate the air refueling tasks and I often caught myself missing necessary steps as the sophistication of the configuration diminished.

P4 Some problems with rendezvouses could still be encountered if an alternate procedure was needed and A/A TACAN became unreliable.

CP4 I tended to answer the questionnaire not only by what happened during the test but also how it would be on a real mission.

P5 Autopilot off and in cell would probably increase piloting tasks more than I visualized.

P8 It was an unnatural time sequence that distorted the problems, not the mockup.

P9 Real time experiences have demands on time not simulated during mockup tests.

How representative of a tanker mission was the mission scenario?

an excellent representation
a good approximation
a fair approximation
a poor approximation
a very bad approximation

Comments:

CP1 It was apparent that a large amount of research and work was done on the mission scenario.

P2 Very close. I suggest that the staff could benefit from aircrew participation in scenario planning. I would be happy to work with them in some capacity to prepare a mission identical to the three scenarios required.

CP2 You people did your homework!

P3 My congratulations to some folks who did their homework well.

CP3 A good approximation of the tougher missions. Normal missions go very smoothly, one in 20. Sounds like yours did.

P4 This was a well rehearsed and well conducted experiment. I believe a great deal of invaluable information will be gained at very low cost.

CP4 For the extent of the working mockup, I thought the representation was excellent. A real time estimate would be better with a working simulator. I see as a real advantage is the fact that a simulator could be set up to really approximate the 135 mission, and basically all the training could be done in a simulator. A large fuel saving with reduction in flight time for nav legs.

P6 I wish we could simulate each mission with all suggested improvements.

P8 TAACE has a crew of people who know pilot experience and pilot talk - super combination.

CP8 You people certainly put a lot of work and thought into this.

P9 It was very obvious that a great deal of preparation went into the mission scenarios. For equipment available, I believe it was an excellent program.

BOOM OPERATOR QUESTIONNAIRE

PRE-MOCKUP

Using Scale I, please rate the adequacy of the present KC-135 boom station:

(1) Overall controls and displays	Day Night
(2) Station lighting	Day Night

Comments:

B01 The position of some instruments and gauges on the overhead panel and pilot and copilot side panels requires the full attention of the individual to operate or read same.

B04 (Difficult at times to observe pilot/copilot instrument panels, especially with I/P or extra crew members occupying jump seat when in cockpit.) At refueling station, would like more positive control with the boom - stability, etc. I think a heads up display would alleviate some A/R incidents. Lighting in the day is good but at night it is poor. To have good night vision, present lighting must be turned real dim.

B05 Boom instrument(s) location requires too much time to scan due to placement. i.e. Too low in relation to where one looks at receiver aircraft. PDI light switches inconvenient and to near override switch. If that switch were in manual configuration, it could accidentally be moved during receiver coaching. Sighting window has too much glare and reflection. Lights must be adjusted to facilitate a non-glare situation rather than user comfort.

B07 I wanted to rate the adequacy of the boom station a "4". The overall viewing area of the boom operator is much too restricted, especially at the side window area. We often have to monitor the position of fighters during deployments. It is very difficult to monitor their position when you can't see them. Controls are fairly simple, although many boom operators complain about having to lay on their belly during refueling. Station lighting is adequate during daytime refueling, however, at night lights can be distracting. If the instruments were displayed in a more subdued manner, it would definitely be more beneficial to the boom operator. One way to improve the lighting would be to have luminous indicators (similar to the watches we use), or to have some kind of semi-transparent covers on lights and gauges to reduce the brightness of the light but retain visibility.

B08 Visual field through sighting window needs increasing. Boom operator platform is uncomfortable and needs redesigning. Ruddevator stick handle needs redesigning. Instructor position needs work for radio equipment, access to controls.

Forward boom station needs adequate storage space for crew equipment. A better method of eliminating the interphone cords which tangle.

Instruments are hard to read with present night lighting (monitoring). Boom operator has no work light,must use nav lighting or turn on cabin lighting. Sun shines on some instruments during day flying. Boom seat in present location: we need more windows or bigger windows for visual work during traffic pattern phase.

B09 Night refuelingsare difficult due to low outside lighting. It is very difficult because at night you lose almost all of outside reference points for depth perception making some contacts very hazardous.

Also it is hard to keep a close watch of the receiver by using the gages because glare from the instrument lights prevent a close watch. And if you turn down the lights, you can't use your gages to keep watch.

Boom controls are in a fairly good setup now. No real comments can be made.

Please rate on a scale of 1 to 10 how willing you would be to perform in-flight duties that you do not now perform (assuming this additional crew responsibility was accomplished with an increase in rating and pay):

Comments:

B01 10, very eager. At the present time during the cruise phase of flight, boredom is a major factor to the boom operator. Any extra tasks would help alleviate this while making the boom operator feel he is a necessary and integral part of the crew.

B04 10, very eager. As long as it is compatible with present duties or especially if it replaces some present duties.

B05 10, very eager. Dependent of course on the particular sum offered. The fact that the tanker's primary role cannot be accomplished without a boom operator indicates we are presently under paid and a raise in pay is justified without an increased workload.

B06 10, very eager. Boom operators main purpose now is refuel and shooting sextant. The rest consists of sitting and watching. I for one would be happy to assume other duties and take some of the load off the pilots.

B07 10, very eager. I feel that a boom operator could do much more during a mission than is presently accomplished. Flight pay (which I'm glad you brought up) is something that should definitely be increased to at least equal what a navigator presently makes. I would be anxious to learn how a boom operator would complete his normal crew duties before flight as well as do the navigator's portion of the preflight. I would also be curious as to how a refueling rendezvous would be accomplished. (SAFELY!)

B08 10, very eager. I think there would have to be much more incentive given to the boom operators to take the extra workload than has been indicated by the AF SAC, etc.

From the following list of items, please indicate which you feel you could perform with no training and those which you could perform with some training (regardless of whether you would be willing to perform them):

Comments:

B07 The only problems I really foresee is that it will be most difficult for the boom operator to accomplish any navigation during refueling. How is the boom operator going to update an INS when he's got eight fighters or so on his tail?

B08 Most of the items marked some training required, I am familiar with. Using our unit as a scale (18 boom operators), 4 are on my level of proficiency, 10 could handle the increased workload if they had the time, the rest could not or would not put in the effort for the increased workload regardless of incentives.

Remember: Our part time guardsmen are limited to amount of time they can give us from their primary civilian employment.

BOOM OPERATOR QUESTIONNAIRE

MINIMAL UPDATE

Please specify any equipment location changes that you would recommend for this configuration:

B01 The radio control box would be more conveniently located on the left side of the navigator's panel.

B02 The communication equipment should be moved to the left hand side of the nav table.

B04 The communication equipment - with radio controls behind pilot's seat, cord is in the way. Only when boom operator is reading checklist is it convenient. Should be positioned at the table.

B05 This configuration seems almost natural and is very easy to adapt to. No change recommended.

B07 APN-69 Rz beacon, back at nav's station. Radar press. cont. at copilot's side panel, along with VHF radio head. Put HF comm head at nav's station, since the boom will more than likely be the primary person monitoring HF. Primary INS should be at nav's station - boom updates and refigures information to insert. Copilot monitors. Boom should have a radar scope to monitor weather.

B08 Leave altimeter at nav station. Leave present nav radar scope in present location.

B09 Recommend an HF console for the nav station for inflight use. The idea of consolidating the annunciator lights as seen in the moderate update is definitely needed. I recommend it be added to this update. The fact one less person aboard to hunt down a problem shows the need.

Was it necessary to have both the center console area and the old nav station accessible to the boom operator? Yes or No

Please briefly explain:

B01 Yes. The old nav table was needed to keep IFR supps. and enroute charts on and is better for filling out paperwork. The center console needs to be accessible to the boom operator to be able to change IFF squawks and the radar configuration (i.e. range, search, intensity, etc.) in the event the pilots are busy at other tasks.

B02 Yes. The INS system on the nav station is good because we can help the copilot put flight plans into it. The center console is good because we can back up the pilot and copilot.

B04 Yes. For crew coordination and it makes the nav checking points easier.

B05 Yes. Most of my attention was focused on the console area,but it's a good idea to have the nav station accessible for writing purposes and to monitor redundant systems. i.e. IFF/SIF and PINS (inertial)

B06 No. There was no need for the boom operator to operate any of the equipment on the center console.

B07 Yes. It's a good idea to have access to both areas. But I could foresee problems with a boom operator trying to make changes to a flight plan, copying altitude clearances, or replanning a mission because of weather, etc.; and having to bounce back and forth to read a checklist, change a IFF/SIF squawk, getting fuel readings, etc. If the boom is going to monitor various systems, they should be at one station to eliminate excess movement and increase the position's efficiency.

B08 Yes. Nav station could be smaller to allow more space in crew cabin.

B09 No. It wasn't really needed, but it could provide greater crew coordination. The boom can assist in changing radar controls, change IFF/SIF codes, and monitor instruments not easily accessible from the nav station.

Assuming that the seat was on an "L" shaped track, did you like the way the jump seat maneuvered between two crew stations?

If no, can you suggest an improvement?

B04 Yes. This is a real good idea even if the nav remains part of a crew.

B07 No. I don't like the idea of having to move around continually. It is a bad idea to have to break a train of thought, especially during a critical phase of flight to check on some nit-noy thing up front. Make the nav's station the boom's primary station. It would possibly be better to have the seat on a diagonal track, if it will be necessary for the boom to move around.

B08 Yes. This would be a good addition for the minimum update.

Identify any additional requirements for the aft boom operator's station that might be necessary for more convenient control operation:

B01 Heads up display for the boom position indicators (i.e. azimuth, telescoping, elevation). I strongly feel that no additional tasks such as operation of refueling pump switches and monitoring of offload totalizer and aircraft totalizer fuel gauges be added to the boom operator during air refueling. Safety of flight dictates the boom operator's attention, it should be on the receiver aircraft position and not monitoring a fuel gauge.

B02 Move the entire gauge panel at a 45° angle facing the boom operator.

B04 Boom operator heads up display would be nice and would keep boom operator from having to take his eyes off the receiver to check receiver positions.

B05 For a minimum reconfiguration the panel remains the same and will work ok.

B06 The boom station could use totalizer gauges.

B07 Larger side windows for better peripheral vision. Luminous instrument markings on all knobs and gauges in the boom pod for night refuelings.

B08 The platform design; larger field of view; instructor access to controls.

B09 In this particular flight, the pilots were greatly involved in navigating in the anchor and assisting in running the rendezvous with GCI. The involvement in the navigating included constant updating plus the communication, and the rendezvous was so much that the idea of putting the A/R pumps in the pod is recommended to decrease some of that workload on the pilots.

Do you feel you had sufficient time to perform "see and avoid" duties while performing other designated tasks? Yes or No

Briefly explain reasons why:

B01 Yes. As long as the crew keeps abreast of the aircraft position as well as their other duties, it seems to be no major problem.

B02 Yes. There was more time for accomplishing nav duties, thus allowing more time for see and avoid.

B04 No. Was quite busy checking positions, worrying about checklists, and listening to radio calls!

B05 Yes. Significant duties up front revolve around communications tasks. Most booms can look outside and use comm equipment simultaneously as it is common during A/R. Most wouldn't be use to talking from the cockpit, at "other" times climb, descent, etc. But any hesitancy would be overcome in a short time.

B07 No. I had my head buried in the checklist. Some of that problem was alleviated however with the new -1 change which allows the crew to accomplish only 1 or 2 items on the Aft. Takeoff Climb checklist, and delay on the remaining items until clear of any possible traffic.

B08 Yes. Cruise phase - no increase in duties over present operation. During takeoff/landing/traffic pattern work, I feel that the increased duties required would take away some "see and avoid" scanning I do now.

B09 Yes. With one pilot flying and the other navigating, the boom operator is just about the only one performing "see and avoid" duties. Yes, I did have time to perform such duties.

Using Scale III, please rate the capabilities presented in this overall cockpit and boom station design to accomplish the A/R mission with a 3-man crew:

Comments:

B01 8. I feel the concept of the 3-man crew is an entirely feasible idea. With ground school training, I don't foresee any problem with the boom operator picking up a great deal of the navigator's present responsibilities.

B02 9. I feel this configuration is sufficient to accomplish an EWO mission.

B04 7. Without capability to set HF frequency, I have to ask the pilot to set a frequency I may need to pass positions or inquire information. Suggest dual head HF be left in this position as is.

B05 9. This configuration displayed how well a 3-man crew could work. It also forced a greater involvement of all concerned and crew coordination improved which is a good thing in any aircraft or configuration.

B06 This configuration needs to be improved. I think there would be trouble with performing a rendezvous or holding an anchor pattern. INS just isn't enough.

B07 I would rate the useability of the INS a nine (9), because once the system is mastered there is really very little work involved with it. However, the design of the cockpit, in my mind, is very impractical and awkward to use for the whole crew!

B08 8. I feel I could function in this position with a minimum of training.

B09 4. As mentioned earlier, the workload with navigation, communication, and the rendezvous is enormous on the pilots. In some situations it might work, but overall it wouldn't work well. One solution, allow the boom to do the communication and perform the rendezvous from the pod. It would reduce some of the load on the pilots.

What percentage of your total workload came from each of the following areas:

Navigation tasks	Weight and balance
Communication tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B01 Since this was the first exposure to this system, a rather small percentage of the time was allotted to "See and Avoid". With increased familiarity, more time could be taken from the paperwork tasks and communications to use for "See and Avoid".

B04 In actuality the boomer may need more time performing his present preflight checklists. Or possibly the ground crew should pick up many of the boom operator preflight checks, except for hatch and cargo door checks. Crew chiefs could perform almost all of present tasks the boom operator does thus freeing him for cockpit assistance.

B05 Not a great deal of free time involved in flight, but quite a bit during preflight which isn't unusual.

B07 Depending on the flight, I would generally foresee more time spent doing navigation tasks and communication tasks. Refueling would normally be a smaller task than either comm or nav duties. However, on fighter drags very little time would actually be spent up front. It is not recommended to leave the boom in trail (unstowed) and unmonitored. If the boom had to navigate between refuelings, then he would have to stow and lower the boom every time he was near a refueling area to accomplish navigation duties. A fighter drag refueling could last 3-3 1/2 hours or more across the pond and the pilot or copilot would have to assume all navigation duties during the refueling.

B09 The only navigation done is on the ground while monitoring the input of the flight plan into the INS system. Communication tasks included launch message and monitoring the HF. The rest of the duties of the present navigator has now been added to the pilots. Not much else has been added to the boom operator.

Using Scale II, please rate your required workload level to accomplish the following during the last mission interval:

Navigation tasks	Weight and balance
Communications tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B05 Workload increased somewhat but would have positive effect because of being more involved thus more useful.

B07 I feel the boom operator could handle more of the communications, except of course during refueling. None of the tasks really seemed that great. If anything, the boom could do more with better location of the navigation equipment.

B08 The spare time that we have now will be taken up by the extra duties. The boom/nav will be a busy person on some flights.

B09 Some navigational duties can be added to the boom to reduce the extreme load on the pilots.

In your opinion, can a 2 pilot/1 boom operator crew safely and adequately perform a mission similar to the one just flown with that same equipment? Yes or No

Briefly explain why (i.e. what was really good and helped you get the job done and what was really bad and hindered your performance):

B01 Yes. The INS was a great deal of help. Without it the feasibility of this program is unrealistic, without sending the boom operator through an entire nav training course.

B02 Yes. The navigation equipment helped save time. There was nothing really bad or hindered my performance.

B04 Yes and No. For the first mission of this type, I felt an awful lot of time was spent with the eyes in the cockpit, spent on paperwork and checklists. Maybe after proper training and working with a crew for awhile this could work nicely.

B05 Yes. Nothing hindered to any extent. I found it easy to adapt to equipment placement. Checklist pacing was a bit awkward but was normal for the first time. In an actual aircraft based on real time, I don't believe there would be any problem at all. I'm sure it would work very well.

B07 Yes. The reading of the checklist to the pilots is a waste of time. It would be better if one of the pilots read the checklist and the boom monitored the pilots' actions. It is much too difficult to read and monitor both pilots.

B08 Yes. I don't think there was any really bad or good, just different. I believe it will be a matter of retraining the boom operator to learn the new task required.

B09 No. The pilots had no way to tell which end was up during the A/R. I had no idea what receivers I had, when they were coming or how much offload they wanted. The pilots had their hands full navigating inside the anchor and communicating with GCI and following directions. But other portions of the flight worked out to a minimum. But the workload was just too much to do it safely. This is a major item.

BOOM OPERATOR QUESTIONNAIRE

MODERATE UPDATE

Please specify any equipment location changes that you would recommend for this configuration:

B01 Boom operator's radio control panel should be moved to the old navigator's instrument panel. During radio transmit configurations (i.e. UHF1 to HF), it is uncomfortable to turn from the nav's table especially when copying messages.

B02 The boom comm should be put on the right side for easy access. (Move the radio panel from I.P. station and put at nav station to prevent reaching back during times when working at the nav table.)

B03 Same comments on the nav equipment.

B04 Comm equipment needs to be at boom's station for easy access. Fuel quantity indicators - hard to see and read from boom operator position.

B07 Like I said before, put some of that stuff at the nav's station for the boom operator.

B08 The fuel control panel and fuel quantity indicators, these two units should be placed together.

B09 The fuel control and fuel quantity indicators should be colocated near each other. All radios should be colocated to give the boom greater access if he is talking on them.

Was it necessary to have both the center console area and the old nav station accessible to the boom operator? Yes or No

Please briefly explain:

B01 Yes. Center console should be accessible to aid with radio frequency changes, radar configuration, etc.; boom operator must have access to the old nav's station because of the boom operator's task of copying messages and map reading. The table is desirable.

B02 Yes. At the nav table the equipment is not needed.

B04 Yes. Easy to copy messages and follow course on map.

B05 No. During exposure to the moderate update system my attention focused almost completly to the front. Perhaps this could be attributed to habit.

B07 No. It would be better to have all the equipment I need at the nav's station.

B08 Yes. Nav station - good work area for paperwork, could be smaller. Center console area - equipment present can be operated by boom operator if necessary.

B09 Yes. In the event the pilots are busy, the boom can operate the controls without interferring with flying the airplane.

Assuming that the seat was on an "L" shaped track, did you like the way the jump seat maneuvered between two crew stations? Yes or No

If no, can you suggest an improvement?

B04 Yes. This is a very good idea!

B06 I did not like the seat in the mockup for any configuration. It needs to be less bulky. If the seat was more comfortable and on an "L" shaped track I'm sure it would be excellent.

B07 No. Perpendicular track to the table, like the present design, or a straight track layed diagonally.

Identify any additional requirements for the aft boom operator's station that might be necessary for more convenient control operation:

B01 Nothing additional, however, I would like to see the A/R pump switches and fuel and totalizer gauges moved forward to the copilot's station. The boom operator's primary function during A/R is to monitor receiver position. Safety of flight is jeopardized with the boom operator tasked to monitor fuel gauges, and without the gauges there is no requirement for the pump switches.

B02 Leave the transferring fuel to the copilot because the boom operator has too much to work with already. (Raise the instrument panel and tilt forward to aid the boom in monitoring both the receiver and the instrument panel simultaneously.)

B04 Boom operator heads up display and direct interphone link with the receiver. Latest receivers in the inventory already have the interphone capability but only the Q model tanker is presently set up for direct talk link-up. Safety in cell refuelings alone would be greatly enhanced and the mod would pay for itself.

B06 The moderate configuration is very good. However, the pumps' lights are really not required, sometimes useful but not a necessity.

B08 Larger field of view - redesign of platform. Instructor needs dual controls or better access to present controls. AR pump controls - we need a start-stop switch on telescope handle. The redesign presented should be selector switches but not start or stop. Transfer and totalizer gages should be located at different locations foward and aft body quantity gages.

B09 A dedicated fuel quantity panel is recommended if the boom is to operate fuel pumps.

Do you feel you had sufficient time to perform "see and avoid" duties while performing other designated tasks? Yes or No

Briefly explain reasons why:

B01 Yes. Addition of navigation hardware allowed extra time for "see and avoid" in spite of the additional workload.

B02 Yes. Once the individual is proficient with these new duties, he will be able to perform these duties as well as he did in the old configuration.

B04 With the moderate I felt at times I was very busy and unable to observe see and avoid, but upon becoming use to the new systems I feel this would be less of a problem.

B06 Yes. Even with monitoring duties, paperwork, etc., there would have been plenty of time to watch out for other traffic.

B07 Yes. There wasn't much to do during takeoff and climb, there cannot be too much to do because like takeoff, refueling and descent are critical phases of flight and it's all "eye work".

B08 Yes. I have as much time in this configuration as I do in the present aircraft.

B09 Yes. Most of the navigation is now in the hands of the pilots now, so the boom just monitors the flight while operating the radios. This gives the boom "see and avoid" time essential to flying.

Using Scale III, please rate the capabilities presented in this overall cockpit and boom station design to accomplish the A/R mission with a 3-man crew:

Comments:

B01 8. The capability for a 3-man crew to carry out a mission of this type with the equipment available in this configuration is entirely feasible.

B02 7. With this configuration thoroughly trained crew members could successfully accomplish this mission.

B04 9. Anything less than the moderate update would increase crew workload to such a degree that a 3-man crew would be unsafe.

B05 9. After flying a "mockup" mission, I feel that flying in an aircraft with this configuration on a real time basis would work very well. It makes the job more interesting. Personally I feel that very little time would be required to train for and transition to this system and successfully perform the mission.

B06 8. Would noticeably enhance mission performance - quite useful. Requirement recommended. Note: My opinion is with a 3-man crew the "nav management system" is necessary to perform the mission.

B07 7. Anytime you can put the nav management CRT, fuel displays, HF radio control, and radar displays and controls, the more useful the boom would be during the flight.

B08 9. I feel that with the proper training (somewhere between minimum to moderate) boom operators could function in this environment.

B09 The boom is still rushed getting the rendezvous and still have time to do the boom pod checklist. (Similar to comments on the major change.)

What percentage of your total workload came from each of the following areas:

Navigation tasks	Weight and balance
Communication tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B01 Did not feel overloaded at all during this mission. However, I still feel the location of the A/R pump switches and fuel quantity and offload totalizer should be moved to the cockpit.

B02 Boom was blinded (simulated) during last part of mission.

B07 The workload was not so demanding that the boom would not be able to do his job.

B08 I feel that with minimum exposure to this moderate update, I could function as well as I do with the current KC-135A configuration.

Using Scale II, please rate your required workload level to accomplish the following during the last mission interval:

Navigation tasks	Weight and balance
Communication tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B01 No indication of any excessive workload. Additional navigation hardware alleviated a great deal of time consuming tasks.

B05 Rated comm at 7 based on a comparison of what I'm used to presently. Booms only communicate with the outside during A/R. Exceptions occur when pilots or nav are very busy.

B08 The scenario presented, while not normal, did not load the boom operator beyond expected capabilities. We are required to monitor the jobs presented today. The difference being, we are not responsible for the completion of these jobs.

B09 Crews must really work together during A/R. The pilots now take care of the radios other than A/R plus navigation. The boom is also kept busy turning on and off the pumps and keeping a watch on the receiver. But I think the crews can do this with some practice.

In your opinion, can a 2 pilot/1 boom operator crew safely and adequately perform a mission similar to the one just flown with that same equipment? Yes or No

Briefly explain why (i.e. what was really good and helped you get the job done and what was really bad and hindered your performance):

B01 Yes. Additional navigation hardware increased the effectiveness of a 3-man crew to perform this mission. The only bad aspect of this configuration is the location of the A/R pump switches and fuel quantity and offload totalizer gauges. They should be moved to the cockpit.

B02 Yes. Only with the proper training and experience.

B03 No. The increased workload in the cockpit when the boom operator was refueling (i.e. inflight emergency, plotting new courses, etc.) resulted in a breakaway call being missed. I believe it's just too much for a 3-man crew to keep up with. This could have happened with the major update also.

B04 Yes. With training and experience, the moderate will work out well.

B05 Yes. Comm eqiupment helped. Having VHF would save time and eliminate confusion particularly in the European theatre. Also liked the AIC-19 mixer box with separate volume controls. A great aid during A/R would be to equip all tankers with boom interphone that's presently installed on KC-135 Q models. It eliminates virtually all radio chatter and confusion because it is more direct. It eliminates missed calls and repeated calls. Many receiver aircrafts are now being equipped with this capability but can only utilize it with Q models. Definitely a must.

B06 Yes. It used the "nav management system".

B07 Yes. The computer displays with the TOLD, fuel quantity, weather displays, etc. would definitely help me get the job done. There was nothing that was really bad.

B08 Yes. I don't feel there was anything really good or bad, just different. I feel it would just take some additional training for the boom operators to perform in the moderate update.

B09 Yes. The crew members have a much greater awareness of what is going on and how it is done. This makes it less easy to make a mistake. Each crew member can crosscheck each other thus enhancing safety in flying.

When transfer fuel flow rate and totalizer, aerial refueling pump switches and aircraft fuel totalizer were provided to you at the boom station, did you:

a) Feel your workload was: increased?
decreased?
stayed the same?

b) Feel that safety was: enhanced?
not affected?
jeopardized?

c) Feel that aerial refueling procedures were: more simplified?
more complicated?
not affected?

Comments:

B01 Safety of flight is jeopardized in that the boom operator's primary task of monitoring receiver aircraft position is interrupted by the monitoring of the offload totalizer gauge while the receiver is in the contact position.

B02 I feel that these additions cause or promote a hazardous situation. It demands too much of the boomer to monitor a receiver and at the same time offload and monitor fuel.

B03 Same comments as with the major update, but to a greater degree with multiple fighters.

B04 Once contact is made with the receiver the boom operator should not be required to take his eyes from the receiver.

B05 Workload - basically the same, negligible increase. Safety - with the added equipment interphone communication is decreased leaving the pilots free for HI monitoring and UHF also. Saves conversation like "Hey copilot how much did he get?" "Er-uh 10,000 pounds, boom." Meanwhile center could be going unnoticed so it enhances safety. A/R procedures: while procedures may change overall it would promote simplicity.

B06 A need for less communication.

B07 Obviously if I had to turn the pumps on, and monitor fuel gages, plus the gages which monitor the receiver in the envelope, my workload would be increased. It's not a good idea to have the boom do all that stuff because sometimes a receiver does not settle down to receive fuel. When he's erratic, the boom had better be ready to call a breakaway, and you need to use both the telescoping lever and the ruddevator control stick at that time. It's ok to have a gage reading offloaded fuel, because the boom could tell the copilot to shut off the pumps. But really, the boom operator should not do any more then absolutely necessary during refueling.

B08 The modifications presented are things a lot of receivers think we control anyway. They would not increase our workload enough to matter. In fact, they would decrease interphone chatter, not detract the pilot/copilot during refueling from flying duties. There will be some concern from the pilot about fuel offload and CG.

B09 It is a great idea putting this extra set of instruments in the boom pod. Safety may be affected when a student is refueling or being refueled. It is hard enough getting your coordination down let alone keeping a good eye on the student receiver. But it's still a good idea.

Using Scale III, please rate how much of a requirement exists for these extra boom station controls/displays in a 3-man (pilot, copilot, boom operator) operations:

Comments:

B01 1. No requirement exists.

B02 3. The offload totalizer and rate gauges are somewhat distracting and unnecessary. A/R pumps may remain, however, they would probably only be used at times when the copilot and pilot are tied up.

B05 Comments contained in previous question will suffice for this also.

B06 Concerning the aft boom station, they would enhance mission performance somewhat - useful but not required.

B07 3. Too many gauges - too few eyeballs!

B08 9. The boom operator can relieve the copilot to coordinate and fly any changes to the mission. The boom operator needs a forward and aft fuel quantity gage on the boom panel to monitor fuel offload since he has no visual way to determine fuel quantities other than total.

B09 7. Workloads are decreased on the pilots so that one can concentrate on flying; the other navigatesinstead adding turning on and off the A/R pumps. One less problem to cause more problems.

Using Scale I, please rate the quality of the layout of the boom station:

Do you have comments or suggestions on how it could be improved?

B01 4. Move A/R pump switches and fuel gauges forward.

B02 4. The instrument panel would be easier to monitor if it was elevated a bit and tilted forward towards the boom position. It is tiring and distracting when looking up and down from receiver to instrument panel.

B04 I don't like the cockpit layout with the radio controls behind the pilot. The interphone cord gets in the way. The new boom station should have his own tuners to tune whatever frequency will be needed.

B05 9. Having never used any system other than the present system in the KC-135, I must say it's good. The moderate update doesn't change it that much. Gauge placement sucks because your eyes have to sweep too far away. Lighting is bad also especially during the day when refueling above a cloud deck. The brightness of the clouds is such that when one tries to focus on the gauges it takes a lot of time. Time enough, in fact, that a receiver could eat you up. Most booms with any significant amount of hours can eyeball the limits, though. At night the sighting window has too much reflection. Lighting must be adjusted to compensate for reflection rather than user comfort.

B07 7. Don't have the boom watching so many gages that he is liable to forget what the receiver is doing. Right now he must watch the receiver, and monitor the gauges (3). If you include a fuel transferred gauge, and a possible gauge for fuel available, then you've got too many gauges and only two eyes.

B08 8. Move forward and aft tank gages and transfer gage under present boom position instruments. totalizer to space beside boom signal coil. Move AR pump selector switches to vicinity of instruments, install start-stop switch(es) on telescope handle.

B09 8. None really.

Using Scale III, please rate the capabilities provided by having weight and balance calculations computerized:

Comments:

B01 9. Excellent idea for time saving.

B02 9. It saves a lot of time. It is more accurate and allows the boom to spend time on more important duties.

B03 0. Could not reach it.

B04 9. Takes away human errors and gives better accuracy and faster computations.

B05 8. Helps with preflight timing. If the copilot uses the computer, he has this information for his takeoff data when he needs it. He doesn't have to wait for the boom or the boom won't have to interrupt/ distract during accomplishment of checklist duties.

B06 8. Would enhance mission performance - very useful. Requirement recommended.

B07 7. It's a convenient idea, and saves time for sure.

B08 7. Would eliminate math errors and be a good crosscheck. However, I don't think it would work to have this information presented first on nav computer. If you are out of limits, the work - aggravation and confusion has just begun.

B09 8. Spontaneous information is given whenever needed. Mostly relieves some of the workload during certain points inflight. Ex: Takeoff and descending when such information is needed.

Using Scale III, please rate the capabilities provided by having take-off and landing data calculations computerized:

Comments:

B01 9. Allows the copilot extra time for more important tasks at the end of the runway just prior to take-off. Also he doesn't have to fool with checklists.

B02 9. It allows pilots to concentrate on navigation and the descent checklist. It is accurate and timely.

B03 0. Could not reach it.

B04 9. Takes away human errors and gives better accuracy and faster computations.

B05 8. As a boom operator,I don't feel qualified to answer as I don't become that involved with the data until after its computed. This question should be directed towards the pilots.

B06 10. Would enhance mission performance greatly,extrememly useful. A very significant time saver.

B07 9. It was great, but should not be absolutely necessary to the point where if the system failed no one would be able to refigure the takeoff data.

B08 9. Would eliminate errors and be a good crosscheck, also would save time compared to present system of manually extracting the information from flight manuals.

B09 8. Easier accessibility during key points during flight.

BOOM OPERATOR QUESTIONNAIRE

MAJOR UPDATE

Please specify any equipment location changes that you would recommend for this configuration:

B01 All the systems were fairly easy to monitor and most items requiring operation by the boom operator were accessible.

B03 HSD very hard to see because of yoke. The nav management CDU should be relocated so the boom operator could operate it to get information for himself and not bother the pilot or copilot (i.e. position for recording on map).

B05 Integrated comm was easy to operate from pilot position but difficult for the boom.

B07 Locate the APN 69 Rz beacon at the nav's station. Locate one of the CRTs that display the nav frequencies (UHF, VHF, TAC, etc.) at the nav's station, and locate a radar set at the nav's station. Also put the CRT which displays the flight plan at the nav's station so the boom operator can more readily utilize the equipment.

B09 Anyone of the radar displays are not easily seen by the boom operator. The closest one is hidden behind the throttles. I'm not sure where it could go. Maybe just a display by the nav station.

Was it necessary to have both the center console area and the old nav station accessible to the boom operator? Yes or No

Please briefly explain:

B01 Yes. The primary reason is the fuel matrix CRT panel operation is necessary by the boom operator and the nav's table is desirable for copying messages and monitoring aircraft position on the chart.

B02 Yes. The nav station is good because when we have to copy messages the table is necessary. The center console is necessary to help the pilot and copilot change radio frequencies and help with radar tuning.

B03 Yes. Center - for monitoring; old - for paperwork.

B04 Yes. Some operations become easier with me being able to call up fuel data without interrupting pilot and copilot duties. Old nav station makes it easier for boom operator to copy messages and follow flight plan.

B05 Yes. Most attention was focused on the center console but the desk is a must. The equipment at the nav station didn't prove very useful.

B06 No. If you moved the CDU to the nav's station.

B07 No. It would be better to have all the major equipment which the boom has to monitor at the nav's station, especially if the boom must update any information. Having to reach in front or to the side of the pilots distracts them and is basically an unsafe procedure. If the boom is going to work any equipment, it should be at one location (preferably the nav's station). Also, put the boom's AIC 18 at the nav's station. It is a hazard to have the cord across the floor and a definite headache to have to turn around to operate the control box.

B08 Yes. Comments on moderate update.

B09 Yes. Because some equipment (fuel MDU) is needed by both copilot and boom operator. It gives the boom operator a chance to check items on the checklist.

Assuming that the seat was on an "L" shaped track, did you like the way the jump seat maneuvered between two crew stations? Yes or No

B02 Yes. Would like to see a swivel installed on the seat.

B04 Yes. Very convenient for boom operator. But where will IP or safety observer sit.

B07 No. Leave the nav's seat on a straight track. Diagonal movement might be all right, however. An L shaped track is a pain because you have to move the seat aft and then left.

B08 Yes. Comments on minimum update.

Identify any additional requirements for the aft boom operator's station that might be necessary for more convenient control operation:

B01 The only addition would be a heads up display for boom position indicators. Once again, I am not satisified with A/R pump switches and fuel quantity indicators on the boom operator's control panel.

B02 I think the pump switches should be left to the copilot.

B03 None that are in conjunction with this mod.

B04 Again I recommend boom operator heads up display. And with fuel pumps and totalizer gages will copilot still control line valve? Possibly boom operator could have a line valve control switch also.

B07 The location of the fuel transferred indicator is ok. Total fuel quantity indicator is not needed. The location of the A/R pump indicator/switches is in an awkward place, and should not be placed there because the left hand should not come off the telescope lever because the breakaway light which is on that handle. If the breakaway switch was on the telescoping lever (on the top) then the placement of the A/R switches would be all right there. The "pounds transferred" indicator would be nice to have, but an accurate indicator is necessary, and it should be easy to read. Once a boom operator has established contact with the boom and the receiver, his hands should not leave either the telescope lever or the ruddevator control stick for safety reasons.

B08 Comments on moderate update.

B09 This subject has been mentioned but is important. If you put A/R pump controls in the boom pod, tank gages are needed.

Do you feel you had sufficient time to perform "see and avoid" duties while performing other designated tasks? Yes or No

Briefly explain reasons why:

B01 Yes. The addition of the nav management CRT and the other hardware takes up a lot of the time consuming tasks, leaving more time for "see and avoid" duties.

B02 Yes. Even with the additional workload,there is still time to see and avoid.

B04 Yes and No. With radio calls and position updates or checking positions, the head is often too much in the cockpit. But time is available for outside scanning.

B05 No. Too busy with comm and checklist duties during most phases of flight.

B06 Yes. Provided the mission was not EWO and curtains were not installed.

B07 Yes. Yes,during takeoff. I would say that I had as much time for "see and avoid" duties as the navigator presently does in a tank today. But less than I presently have as a boom.

B08 Yes. Comments on moderate update.

B09 Yes. After takeoff, my duties weren't too much, so I had time to act to see and avoid.

Using Scale III, please rate the capabilities presented in this overall cockpit and boom station design to accomplish the A/R mission with a 3-man crew:

Comments:

B01 7. With the dual INS and additional hardware associated with this modification, I see no problem for a 3-man crew to accomplish the mission.

B02 7. I don't see any problem with the 3-man crew to get the mission done.

B04 9. Without a navigator it would be extremely difficult to accomplish a 3-man crew mission with the major package.

B05 [illegible] Equipment requires too much time to set up during preflight and during flight. Pilots are too occupied during critical phases of flight. Causes confusion as to who is actually controlling the aircraft and too little time for see and avoid.

B06 Would enhance mission performance greatly - extremely useful. Requirement recommended. The 3 man crew concept is excellent.

B07 Pain in the ass for the boom. I cannot perform my job efficiently with all the equipment I need located by the pilots' seats. I need something at the nav's station in order to be any kind of an aid for the pilots. In fact the more equipment you put back there the better, except for what indicators they need to actually fly the aircraft. Plus I don't think it's too great to have all those CRTs up there especially when flying at night. That's too much light in the cockpit.

B08 Comments on moderate update.

B09 8. Workload on the boom because he is running the rendezvous and still has to go to the pod and complete checklists back there. The boom is really being rushed.

What percentage of your total workload came from each of the following areas:

Navigation tasks	Weight and balance
Communication tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B01 The only time the boom operator would be exceptionally tasked would be during multiple refuelings. Therefore, I advocate relocation of the A/R pump switches and fuel quantity gauges from the boom operator's control panel to the front of the aircraft.

B05 Too little time for see and avoid. Comm was a little hectic but would improve with time. Nav was sort of tough due to lack of knowledge but would improve.

B07 Other - 90%. Moving around the airplane.

B08 On TTF missions (fighter drags), the boom operator is in the pod most of the flight.

B09 A lot of the time was spent on making radio calls or monitoring them. Most booms are not quite ready for such a task.

Using Scale II, please rate your required workload level to accomplish the following during the last mission interval:

Navigation tasks	Weight and balance
Communications tasks	See and avoid
Aerial refueling tasks	Free time
Paperwork tasks	Other (not listed above)
Fuel management	

Comments:

B01 No excessive workload except during A/R.

B03 Preflight - 7; Read checklists - 4.

B05 Too little time for see and avoid. Comm and nav seemed to require lots of time, but only because it was new and unfamiliar. Paperwork was more than I could keep up with, but I could adapt in time.

B07 I don't believe you have given enough for the boom to do. I would definitely be more beneficial to the 3-man crew idea if I could display what the crew wanted on their various displays from the back, so they could spend more time flying the airplane.

B08 Boom operators will be busy on this configuration,but I don't think the task will be more than the boom operator can safely do. Tests have been conducted on tactical missions. Passenger hauling would put an increased workload on the boom operator. Possibility of having two boom operators on pax hauling - tactical missions.

B09 Once a boom learns to navigate, the workload may increase some. During this mission, I let the pilots do the navigation.

In your opinion, can a 2 pilot/1 boom operator crew safely and adequately perform a mission similar to the one just flown with that same equipment? Yes or No

Briefly explain why (i.e. what was really good and helped you get the job done and what was really bad and hindered your performance):

B01 Yes. The INS was the really mandatory modification required. The additional CRTs aided the crew immensely.

B02 Yes. The good part is the addition of the navigation equipment and computers. The bad part was the location of the pump switches and fuel gauges in the boom pod.

B03 Yes. With proper training and ideal conditions. However, there could be times when 3 men could be hard pressed to keep up with what's happening (i.e. during in-flight emergencies).

B04 Yes. Without equipment failure the mission can be performed.

B05 Yes. An experienced crew could transition to this configuration and perform safely and adequately, but a new crew would have trouble. Most equipment was so much different that it detracted from mission accomplishment. This configuration would work but it would require an extensive training program.

B06 Yes. The nav management system is exceptional. The CDU is a super time saver and the fuel management takes a load off the copilot and boom. However, crew should have more than one morning to familiarize themselves with these systems.

B07 Yes. The flight could be accomplished safely if the equipment was located at the nav station, but not safely if located at the present location. Moving around the airplane is too much of a distraction.

B08 Yes. I did not contribute much to the pilots after air refueling was started. So I believe with this mod, they are able to handle similar missions with equipment provided.

B09 Yes. Each crew member has anincreased awareness of what is going on. The job requirements flow together easier. I have a greater knowledge over fuel management, navigation and just plain flying the airplane. I can actually perform, not just watch.

When transfer fuel flow rate and totalizer, aerial refueling pump switches and aircraft fuel totalizer were provided to you at the boom station, did you:

a) Feel your workload was: increased?
decreased?
stayed the same?

b) Feel that safety was: enhanced?
not affected?
jeopardized?

c) Feel that aerial refueling procedures were: more simplified?
more complicated?
not affected?

Comments:

B01 During this period boom operator attention should be focused on the receiver aircraft position and not monitoring offload totalizer and aircraft totalizer gauges.

B02 Pump switches should be left to the cockpit.

B03 Boom operators presently have enough to do in the pod without adding any more switches or gauges. To do so would be more of a distraction and jeopardize safety, especially with an unstable or erratic receiver on the boom. The offload totalizer could be of some value as it would enable the boom operator to give the receiver his offload report,thus reducing interphone communications between boom operator and copilot.

B04 Anytime the boom operator has to take his eyes off the receiver to actuate a pump switch it is a safety hazard. The offload totalizer gage is an asset though as it saves an interphone call and won't interrupt the crew.

B05 A) Slight increase because of added equipment. Monitoring the gauges and using pumps would not increase the workload to any great degree. B) Safety is enhanced because the copilot doesn't become distracted with interphone calls which could cause him to miss traffic calls or clearances. C) Yes,it centralizes procedures around the boom operator.

B06 Aerial refueling was more simplified in that communication, the pumps being on and the receiver was or wasn't taking fuel, was not needed. During cell refueling,this itself would be very important.

B07 See answer to the fourth question.

B08 Comments on moderate update.

B09 The only problem I saw with the A/R switches is in the case of bad weather or an inexperienced receiver. You need both hands on the controls to insure safety. The only way the procedures were more complicated was because of the above.

Using Scale III, please rate how much of a requirement exists for these extra boom station controls/displays in 3-man (pilot, copilot, boom operator) operations:

Comments:

B01 0. See comments on previous question.

B02 3. Pump switches should be left to copilot.

B04 10. The only thing I feel unneeded in the boom pod is the fuel pumps. The frontend crew (pilot and copilot) still has to set up the tanks for offload. Up front in the cockpit, anything that is extra at the boom station and helps crew coordination is good. The boom operator still needs his radio controls over at his station as interphone cord is still in the way at his present station.

B05 9. Pump switches aren't really required but I recommend the gages.

B07 At the boom's forward station he should have a radar, the radio control box, rendezvous beacon, control box, the flight plan display CRT, and a fuel control CRT to eliminate all that movement! Presently, I would rate the requirements about a "5". It's nice to have but some of the equipment is probably not absolutely necessary.

B08 Comments on moderate update.

B09 7. Usually the pilots up front have very little to do during A/R, so I'm not sure if it is really a requirement but it could be used to an advantage in most refuelings.

Using Scale I, please rate the quality of the layout of the boom station:

Do you have comments or suggestions on how it could be improved?

B01 2. Overall layout was adequate except for the location of the A/R pump switches and fuel quantity indicators. They should be relocated to the front of the aircraft.

B02 4. Pump switches should be left to the copilot.

B03 9. Present layout (excluding the new switches and gauges which I feel aren't required) is very good. Other type improvements on present equipment are required, i.e. capability to set own limits, reposition boom position indicators, boom trim switch, etc.

B04 7. (In the boom pod) A positive disconnect system is needed despite receiver configuration, or position in the A/R envelope. In the cockpit, I rate it a 7.

B05 7. The gauges require too great of an eye sweep. Lighting at night reflects off sighting window requiring light adjustment. To reduce glare rather than accommodate operator, pilot director lights should be moved or have different shaped switches so as to eliminate confusion between override switch and the limit active/inactive switches.

B07 1. Refer to question #2.

B08 Same comments on moderate update.

B09 7. The position of A/R pump switches just forward is a good position because right after a contact the hand is free for just long enough to activate the pumps. No real improvements can be made right now.

Using Scale III, please rate the capabilities provided by having weight and balance calculations computerized:

Comments:

B01 9. Excellent idea.

B02 9. It saves time and is more accurate.

B03 9. With the correct information fed to the computer, the system would definitely cut down the time required to compute CGs. Also, it would eliminate human errors presently being made.

B04 9. Leaves out chances of error on part of boom operator. With capabilities to call up weight and balance at anytime, pilot or copilot have constant weight and balance at their command.

B05 9. Computer use was awkward at first, but would surely be a good thing to have after I learned to use it. I liked it.

B07 5. That's great, but the location of the computer is a drag.

B08 Comments on moderate update.

B09 9. You can now get instantaneous calculations for cases of emergency or no time instead of spending several minutes on a load adjuster.

Using Scale III, please rate the capabilities provided by having take-off and landing data calculations computerized:

Comments:

B01 9. Good time saving modification.

B02 9. It saves time and is more accurate.

B03 9. With the correct information fed to the computer, the system would definitely cut down the time required to compute the calculations. Also, it would eliminate human errors presently being made.

B04 9. Less chance of error on part of boom operator.

B05 9. Again computer use was awkward, but even to a greater degree because I'm not very familiar with takeoff data. I could adapt with more training. Its good because it reduces copilot workload which appeared excessive in this configuration.

B07 7. That's great too, but again, there will be some data I need that I have to look up front to get, and it would be a lot better to have the equipment in a more accessible location.

B08 Comments on moderate update.

B09 9. It allows the pilots to work on landing the airplane and keeping their heads up. Quick and easily access.

Using Scale III, please rate the capabilities provided by having automatic/ programmable fuel management:

Comments:

B02 9. It saves time and you don't have to worry about it and leaves more time to see and avoid.

B04 9. Excellent - fuel economy should be greatly increased, and savings will be noticeable.

B05 I didn't have a chance to become familiar with this equipment. The copilot operated it. Sorry!

B07 7. It's a nice function. Takes a lot less time to get a reading and give the pilot a CG and fuel remaining.

B08 5. Would be nice to have, but I don't feel it is necessary.

B09 7. Decreases some of the workload on the pilots and allows them to navigate.

Using Scale III, please rate the capabilities provided by having checklists on a CRT (as opposed to the conventional binder):

Normal checklists
Emergency checklists

Comments:

B01 8, 9. Much more convenient for normal checklists. Also saves a great deal of time for emergency checklists.

B02 9, 9. Leaves your hands free for additional tasks.

B03 3, 9. Didn't really see any great advantage with normal checklists. However, the caution and warning annunciator panel would greatly reduce time required to research a problem in the -1.

B04 9, 9. Leaves hands free to have better access to controls and switches, and less chance of omitting checklist items.

B05 3. No emergency checklist use. As for normal checklist useage, I'd much rather have the conventional binder. In actual useage of a real unit I might change my mind, but I doubt it.

B06 5, 4. This part of a CRT is useful, but I prefer the conventional binder. The CRT might be more convenient and might even be faster when looking up Emergency checklists.

B07 7, 5. Suppose your problem is electrical and your checklist is not available on the CRT. It's better to just have a normal checklist binder.

B08 3, 3. Normal: I can see problems in currency and we still are going to have paper checklist. Emergency: The call up theory is excellent as long as the unit does not fail. Location of readout is bad for pilot and copilot if boom operator is gone from forward position.

B09 6, 8. Emergency checklists, again, provide easier access especially in an emergency operation.

BOOM OPERATOR QUESTIONNAIRE

POST MOCKUP

Please rate on a scale of 1 to 10 how willing you would be to perform in-flight duties that you do not now perform (assuming this additiona crew responsibility was accomplished with an increase in rating and pay):

Comments:

B01 10, very eager. The pay raise and increase in rate would have to be commensurate with the amount of additional responsibilities. But I do feel that the additional responsibilities would help to make the boom operator feel like a more integral part of the crew along with an increased sense of accomplishment during the mission.

B02 10, very eager. If I did get an increase in rating and pay.

B03 8. Depends on how much of a rating and pay increase.

B04 10. This is long overdue especially in rating, even under present duties.

B05 10. More pay is naturally something I would want, but as I stated in the first questionnaire the tankers primary mission cannot be accomplished without a boom operator. So we are presently underpaid and a raise would be justified without any additional duties.

B07 10, very eager. I think it would be a great idea to let the boom handle a lot of the present navigator duties, but definitely only if I got increased pay and rating.

B08 10, very eager. I feel that most of the present boom operators would be willing to upgrade within the program. Also this upgrade would probably attract quality people and help with the retainability problem faced today, if the increase in pay and rating was built into the program.

B09 8. I feel most boom operators would be willing to accept the additional duties. Most don't have anything to do other than A/R. I, personally, am very interested in learning such things as navigating and fuel management.

From the following list of items, please indicate which you feel you could perform with no training and those which you could perform with some training (regardless of whether you would be willing to perform them):

Comments:

B05 Those items listed that require training are basicly familiar to most booms who have flown 700 hours or so. Training in most instances would be minimal.

B07 I realize that it would take some training, but I'd enjoy it (I think).

B08 Most boom operators are familiar with all tasks listed. Amount of additional training required would depend on amount of experience. Any experienced boom operator would be able to learn the task with a moderate amount of training. The training required to train a new boom operator without any prior experience would be quite extensive.

B09 None.

How realistic was the mockup experience?

Comments:

B01 b) A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the simulation.

The simulation of ground control agencies and other aircraft by the engineers was excellent and aided greatly to the realism of the mockup flight.

B02 b) A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the simulation.

You would have more time in the airplane to do your duties. You wouldn't be rushed as much.

B04 c) Similar to a real experience; you had some difficulty imagining yourself in an actual flight.

With the mockup as a boom operator, I could not realize actual timing in running my cargo compartment, boom compartment, checklist. I suspect time in the cargo compartment will take away from cockpit duties on the ground. I recommend the crew chiefs pick up all present checklist items from the cargo compartment and boom pod, except for hatches and cargo door. The ground mechanics could easily preflight the cargo compartment and the boom operator would still secure cargo.

B05 b) A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the situation.

For the most part the mockup seemed realistic. Especially the communications. Running checklists where equipment was missing or fake was difficult but it worked well enough.

B07 d) Although unreal, it aided in role playing and, therefore, enhanced the realism of the flight.

Some parts were well done, but once an emergency situation came along it got a little out of hand. The flight was realistic in the respect that, that is probably the way we would fly without a navigator (ha, ha!).

B08 b) A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the situation.

The mockup was more than adequate for the project. All the realism needed was supplied. It was not hard for me to identify with the mission.

B09 b) A close approximation; you could imagine being in an actual flight, but you were always aware of the artificiality of the situation.

The operators did a very good job in trying to simulate the new devices in use. The nav management CDU made more realistic in trying to put all the new devices all together to get the feeling of flight. A lot of imagination was needed by the crews to get necessary feedback. The operators also did a good job in positioning the new devices. There were just a few real changes needed, but that always happens.

How did the unrealistic aspects of the mockup influence your answers on the questionnaire? Were you most likely to underestimate or overestimate the difficulty of the following tasks?

Communication tasks	A/R tasks
Navigation tasks	Rz tasks
Paperwork tasks	Other tasks (not listed above)

Comments:

B01 I tried to overcome the unrealistic aspects and project myself into the role as much as possible.

B02 I over estimate because of my unfamiliarity with these tasks.

B07 I'm sure SAC would still require a great deal of paperwork and a great deal of navigation work. Since I am not really trained in navigation, and I don't talk to ground much, I was a little rough sometimes on the radio.

B08 Underestimation is based on my not knowing for sure what is involved in the task rather than the mockup.

B09 Navigation wasn't really quite understood at the beginning because the crews weren't able to comprehend, so that is why the tasks were really underestimated.

How representative of a tanker mission was the mission scenario?

Comments:

B05 b) a good approximation. The timing was certainly awkward. But otherwise it was very close to reality.

B07 b) a good approximation. The flight plan and mission seemed pretty realistic. Hopefully,we don't have all those problems, however, because I'd flat quit flying.

B08 a) an excellent representation. You covered it all.

B09 a) an excellent representation. The three missions flown simulated real life flights very well. The scenarios represented normal flight flown everyday, especially out of Plattsburgh. Job well done!

DEBRIEFING COMMENTS

Crews 1, 2, 3

MINIMUM CONFIGURATION

- Doppler and TAS: switch them
- Beacon, etc. all up forward → all 3 crew members should be able to reach them.
- Center console IFF, flaps, etc.

  One pilot thought it was awkward to work the rudder power switch, but everyone else adjusted to where it was placed.

- Pilot side panel: AIC-18 not an absolute requirement but it is nice to have. It does give you VHF.

General Comments on Minimum Configuration

- Weakest portion of the configuration is the radar: pilots must be able to see it: they can't at present.
- Radar is in a bad location was a general consensus among pilots.
- Minimum insufficiency for the anchor: mod and maj map displays would have been great because now there is no way to monitor position and deviations with minimum modification.
- ARA on the radar scope is practically impossible.
- Crew coordination becomes especially important: experience level of boom operators becomes a major factor.
- Minimum update INS needs range (RNG) and bearing (BRG) capability.
- Bearing and distance from a nav aid and waypoint would be extremely helpful.
- Nav system on minimum update without a navigator can't cut it.
- At times, safety would have been compromised.
- Simulator training would be helpful.
- Pilots need table to plot JN charts.
- With NAV aids turned off, INS does not have enough display area.

MODERATE CONFIGURATION

- The HSD was blocked by the yoke and was extremely hard for the boom operator to see. All members thought the represented capabilities of the HSD were great and suggested they be absolutely mandatory without a navigator.

- All crew members thought a digital hack clock would be helpful. Only one would be necessary as long as everyone could see it, and a digital type would reduce parallax.

- Tape instruments vs. round dial
  - It's easier to visually line up tapes
  - Tapes for AOA and radar altimeter would be nice but the round dials suffice. AOA principally used as a reference and not as a primary instrument.

- BDHI vs. RMI
  - No consensus on which was preferred.

- In case of failures, the switching capabilities between the HSDs becomes very important.

Center Panel

- Master caution panel would greatly enhance flight safety. One pilot thought it was a requirement.

- Good to have C/W indicators consolidated.

- Probably going to need digital readouts for the tapes. Selectable EGT, RPM, EPR digital readouts are sufficient, and a requirement for engine parameters.

- Perhaps the lights should blink before going to constant on for the C/W panel.

Overhead Panel

- Talking about cost constraints: it may not be necessary to move some of the switches.

- Some groupings can be confusing because you really have to look for what you want.

- Boom operator should become more proficient in his job.

Moderate Update General Comments

- On switching panels: functions of switches for normal flight should be lined up and all switches should be pointing in the same direction when in normal operation.

- *There may be a problem of switch identification with so many switches* on one panel.

- Gear handle needs to be shortened: it hides the nav management CDU on the copilot's side.

- Put the boom engage light on fuel panel.

- Need gages and switches closer together: don't separate them.

- There was conflicting opinions on the need for automatic fuel programming.

- There may not be a need for two nav management CDUs in the represented locations: put a keyboard back where the boom operator can reach it.

- Totalizer A/C fuel was not necessary on boom station.

- Offload totalizer and rate gages were nice, but not necessary at boom station.

- CG display should not be in the back.

- Split opinion on whether three men could fly the mission.

MAJOR CONFIGURATION

Center Panel

- Nice to have checklists automated, but not required.

- Split opinions on the necessity of the consolidated C/W panel vs. the alphanumeric readout panel.

- Preferred AHRS on the engine instrument panel, but AHRS on the overhead panel would be better with automated lat/long update.

Aft Center Console

- No reasoning behind the switching matrix: it would be too tough for newcomers to learn. Also would be too easy to actuate the switches because of their location.

- A miniaturization of the existing fuel panel would be ideal.

Pilot/Copilot Side Panels

- Need drink holders because nothing was there.

- Did not like the "hot-mic" feature of the AIC-18s.

Overhead Panel

- Generally liked the hydraulic, anti-ice, and instrument power switches close to the pilot.

- It was reasonable to have the beacon operated by the copilot.

- If the switches are miniaturized, they will need guards.

- Liked the central locations of the comm/nav tuners, but the tuners were not essential -- just nice to have.

- The Doppler and radar were located in good spots.

Boom Station

- Totalizers cut down on necessary intercom chatter. However, they are not a requirement.

- Boom engage light is not necessary.

General Comments for Major Update

- Gear down: can't see the INS scope from copilot's seat.

- Co-location of gauges and switches for fuel panel would be better: don't separate them.

- Put the boom engage light on the center panel.

- Didn't like not having a "visual tracer" of fuel flow: the diagram is very helpful.

- Fuel transfer and CG were big concerns: need some sort of automatic CG or fuel transfer.

- Nav management system was inaccessible to the boom operator and the lettering was too small: he couldn't reach or read it very well.

- A third keyboard accessible to all 3 crew members might be a good idea: a third screen for the boom operator probably wouldn't be necessary, but a keyboard for the boom helps for CG computation, fuel management, TOLD, etc.

- Want color displays for HSD and definitely for WX. If the only way color can be put into the cockpit is through a third CRT for weather, then that CRT should be a requirement.

- An auto fuel panel and CDU for the boom operator added to the major system would make it probable that it could be flown with three people.

- SELCAL would relieve the pilots: worth looking at the cost of implementation.

- Boom AIC 18 should be on the old nav station.

- Need fourth crew member for carrying pax and cargo.

- Booms reading checklists was a very good idea.

- Qualifications of maintenance personnel is a limiting factor and a potential problem.

- With everything working, a 3-man crew could operate the moderate and major systems and accomplish the mission.

DEBRIEFING COMMENTS

Crews 4, 5, 6

MINIMUM CONFIGURATION

- The general consensus was that the air refueling mission could be accomplished with this configuration, but that the radar would have to be greatly upgraded.

- The present radar is insufficient during rendezvous and ARA procedures. For EWO situations it would be nearly totally useless. Moving the crack would be extremely difficult with wx or other problems.

- An HF control should be included on the old nav station.

MODERATE CONFIGURATION

Front Panel

- Would like the capability to read both TACAN distances with two DME readouts. Not necessary, but highly desirable.

- Tape instruments and digital readouts were much better than the round dial instruments. They provided a smaller scanning area, were easier to interpret, and were simply easier to see. Although one copilot wanted digital readouts for all tapes simultaneously, the selector function was well liked. Digital readout for EPR is critical.

- Annunciator lights on C/W panel: required.

  - All crew members liked the central location, but a few expressed concern that the AR pumps and comparator lights would come on too often. Consider eliminating those.

Overhead Panel

- The copilot couldn't reach the APN 69 during rendezvous.

- All liked the centralization of the systems switches, but agreed that the mini-toggles should be more guarded or the "lock in place" type.

Forward Center Console

- A pictorial rendering of the fuel flow is a necessity for matrix switching. Reduce, if possible, what is being used now.

- Liked the approach plate holders.

- They preferred two nav management systems, but the boom operators worried about the accessibility of either of them for boom usage. Solution: another keyboard for the boom.

- Pilots and copilots liked the throttle quadrant and associated switches.

- Fuel matrix:
  - Might not be able to read the switches too well (lighting difficulty).
  - Wanted co-location of tapes and switches.
  - Both pilots should be able to get to radar.

- It would be very desirable to have a radio transmitter selector on the yoke.

Boom Operator's Station

- AR pump switches not wanted on the boom station. Transfer fuel totalizer and rate gage are good. Aircraft totalizer is not necessary.

- Present transfer totalizer inaccurate: a new system is needed.

- A system to hook up intercom between tanker and receiver when contact is made is necessary. Q model has it but "A" doesn't.

General Comments for the Moderate Update

- A 3-man crew could fly this configuration and successfully accomplish the mission.

- The nav management system was the key insuring mission accomplishment.

MAJOR CONFIGURATION

Front Panel

- Digital C/W unnecessary.

- Selectable BDHI: not necessary but nice to have.

- ADF was very useful but not required.

- Non-directional beacon would be very nice to have but is not quite a requirement.

- You could get by with one bearing pointer, but two would be nice to have on the HSD.

- AHRS was poorly located: move to overhead panel.

- It would be helpful to be able to tie one nav aid into auxiliary power to ease nav without electrical power.

- No need to update ADI or FD109.

- Integrated comm/nav units were nice but unnecessary.

- Too many CRTs in this design
  - Center CRT only necessary if it is the only way to get color wx radar.
  - Fuel management CDU would be unnecessary if the function were put on the nav management system and the boom operator was given access to a keyboard.

General Comments for Major Update

- May not really have the time to watch half a dozen TV screens.

- Reasonable to give the boom operator a CDU in back and then stay reasonably close to the moderate configuration.

Final Comments

- One boom operator didn't care for the pull switches on AIC-18.

- Mixed comments on leaving the sextant on board.

- Throttles blocked the INS in the minimal update.

- Boom operators would really like the added responsibility (as a general consensus).

- Not really sure if the boom fuel pumping controls at the boom station would offload the copilot to a significant degree. Consensus: the back-end pumps are not necessary.

- They never use a "G" meter.

Scenario Comments

- Loring Departure - Have TAACE tanker abort for water rather than hydraulic leak on strut.

- Unrealistic to be able to meet other tankers exactly over first rz.

- Mildenhall EWO - ok

- Bodo/Aalborg - ok

DEBRIEFING COMMENTS

Crews 7, 8, 9

MINIMUM CONFIGURATION

- Doubtful that any of the missions could be flown with minimum configuration. Either a second aircraft or GCI would be replacing the navigator.

- Mach airspeed indicator: prefer digital readout of airspeed rather than Mach digital readout.

- Pilot side panel: HF is a one man operation, so boom had poor access to it.

- Copilot side panel: Same comment on VHF as HF above. Ciphony position should be re-evaluated.

- Fighter drag: No real consensus if could be flown with minimum. (Leaned toward couldn't be done, single ship.)

- EWO mission: Make copilot a nav and sit him at nav table.

- Bodo recovery: 50/50 on ARA being successful.

- Contingency mission: Too many responsibilities for the copilot -- easy to handle in the mockup, but not in real life. A new nav would have difficulty let alone without a nav.

MODERATE CONFIGURATION

Front Panel, Overhead Panel, and Center Pedestal

- Instead of drum mach, give drum knots (MAS indicator).

- AOA: This didn't give trend data -- would prefer trend data.

- HSD with the yoke in the way is unacceptable. A look thru yoke would be much better.

- Need updated marker beacon lights.

- The ADF is old, but it's still a good aid.

- Would like hydraulic switches nearer to the gages. One person thought C/W system was sufficient and that the "tape instrument" area would be better suited for the fuel panel.

- Don't put oil pressure overhead.

- Like checklist (dedicated C/W panel) procedures better than the "prioritized" panel idea.

- Didn't care for HSD selector. On the center of the yoke might be better or on the right hand side of the HSD for the pilot.

- Put a boom engage light on the fuel panel.

- Good to be able to stop fuel pumps from the boom station, but not to start them. The A/R pumps in the boom station should be on the stick if they are determined to be necessary.

- Miniaturize the panels infrequently used and those that are used a lot keep large.

- Rz beacon should have been closer to the copilot. Copilot can't reach it wnere it is. Maybe switch it with the light controls.

- A caution light is needed for radar pressurization.

- Electrical and pressurization panel should be redesigned so that regular size switches can be used on other switching panels thus making more overhead panel space available.

- Rendezvous beacon capability needs to be checked with the possibility of using the IFF/SIF rather than the beacon. Make it compatible with all aircraft.

- Explore the possibility of selectively printing out nav data for recording purposes rather than manual recording.

- Need a system to compute fuel remaining vs. fuel required on nav's management system.

- Anti-ice should have a 60 second flight start sequence which comes on automatically whenever flight start selection is made.

- Need a program on the nav management system for preflight planning to show fuel remaining past each waypoint and for use in flight.

- Need a program that would enable the insertion of predicted winds for flight planning.

- Some expressed concern that the boomers would get too overloaded -- they are already extremely busy during certain segments as it is.

- Calculator function on the nav management system would be very helpful.

- Program a specific offload capability (500#, 1000#, etc.) so that a boomer does not have to watch the gages when he has a "squirrelly" receiver.

- Need a cassette to load flight plans into aircraft.

- For HSD formats you need a cursor to a beacon.

- Check what happens if AHRS fails: is that the only heading input into the nav management system?

MAJOR CONFIGURATION

Front, Center, and Overhead Panels

- It was confusing to have a mode selector on the BDHI.

- TACAN arc to ILS final: putting the exact letdown plate on the HSD would solve the problem.

- Investigate the possibility of backup gyros in case AHRS fails.

- Yoke cuts off HSD.

- One boom didn't like checklists on CRT.

- One pilot liked the center radar; most thought it depended on the clutter but that generally it was overkill.

- Didn't like integrated comm/nav; might prefer it with simple channel change. Some thought it was nice -- none thought it was required.

- Interphone contact with receiver should be improved.

- Put a gear warning cutout on one of the yoke horns.

- SELCAL is nearly a requirement.

- Would like a pitch set feature (attitude hold) on the flight director/autopilot.

- Would like an altitude reminder.

- Need a display for precomputed MRT for climbs.

Boom Station for Moderate and Major Updates

- Quantity gages per (center) tank.

- Thumb switches would be helpful.

- Thought (B/O's and pilots) that an override system and boom pump controls would help to unload the pilots. But copilots must always be able to seize control if necessary.

- Reading the gages at the boom station during refueling may be dangerous. Therefore, automatic sensing devices would be helpful for safety reasons.

General Comments

- As a general consensus, there would have been no problem flying the moderate or major systems on any of the represented missions.

- Comm was a very important part of the mockup concept.

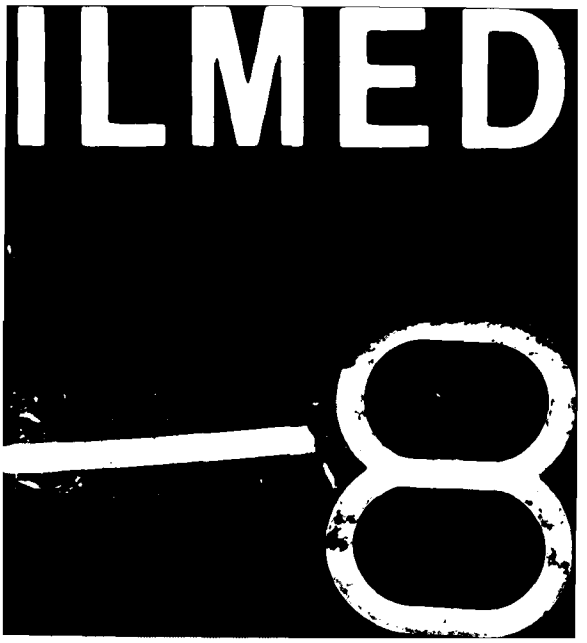
- A basic training mission maybe should have been looked at.

- Most cell keeping is done off radar.

- Sometimes it is more important to simulate the head-down situation.

- Give a major system failure next time this procedure is done.

*U.S.Government Printing Office: 1980 — 657-084/776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